MECHANICAL EPISTEMOLOGY AND MIXED MATHEMATICS:

Descartes's Problems and Hobbes's Unity

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Descartes's Problems and Hobbes's Unity

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University of Pittsburgh, 2014

My dissertation answers what appears to be a simple question: How is Hobbes's politics related to his physics and metaphysics? However, answering this question has proved more difficult for scholars than it appears at first glance, and there has there has been no consensus in the literature over the past fifty years. Two well-represented extremes dominate the literature: the first view claims that Hobbes's politics is deduced from his physics and ultimately his metaphysics; and the second view claims that the politics arose independently of Hobbes's other work. My dissertation argues that Hobbes does in fact provide a unified systematic philosophy, and I contrast this unity with problems in Descartes's epistemology and optics. To make this argument, I carve a middle way between the two extremes in the literature by situating Hobbes within mechanical philosophy and 17th century mathematics.

I use three concepts to clarify Hobbes's project: mechanical explanation, maker's knowledge, and mixed mathematical science. First, I show that for Hobbes a mechanical explanation involves tracing the motions of bodies at various levels of complexity, from simple points in geometry to human bodies in the state of nature and to commonwealth bodies. This view provides Hobbes with resources for a naturalized epistemology, which I show is the point at issue in Hobbes's Objections to Descartes's *Meditations*. Second, Hobbes says that we have "maker's knowledge" in geometry and politics. I show that "maker's knowledge" is Hobbes's

empiricist answer to (1) how we have causal knowledge in politics and mathematics by constructing and (2) how mathematics is applicable to the world. Finally, I show that the mixed mathematical sciences, e.g., optics, were Hobbes's inspiration for a unified philosophical system. I argue that the physics in *De corpore*, the optics in *De homine*, and the politics in *Leviathan* are treated by Hobbes as mixed mathematical sciences, which provides a new way to see Hobbes as a consistent and non-reductive naturalist. Viewed in this light, the *Leviathan* turns out to have more methodological similarities to optics than to geometry.

TABLE OF CONTENTS

PREFACE ..... **XI**

1.0 INTRODUCTION **1**

1.1 HOBBES AND THE UNITY OF THE SCIENCES **1**

1.2 UNIFIED VERSUS DISJOINT SCIENCES **4**

2.0 THE WAX AND THE MECHANICAL MIND: REEXAMINING HOBBES'S OBJECTIONS TO DESCARTES'S *MEDITATIONS* **9**

2.1 INTRODUCTION **9**

2.2 THE WAX IN THE SECOND MEDITATION AND HOBBES'S OBJECTION **12**

2.2.1 "Tak[ing] off the clothes, as it were": Descartes's Method and the Wax. **12**

2.2.2 Hobbes's Objection: Conceiving versus Perceiving and Reasoning as the "Linking of Names" **15**

2.3 A MECHANICAL EPISTEMOLOGY FOR MECHANICAL MINDS **17**

2.3.1 Hobbes's Philosophical Psychology: Stages 1 and 2 of the Mechanism ... **17**

2.3.2 From the Mechanical Mind to Mechanical Epistemology: Stages 3 and 5 of the Mechanism **22**

2.3.2.1 Conceptions and Language **22**

2.3.2.2 The Activity of Philosophizing **26**

2.3.2.3 Questioning an Epistemology of Simplest Conceptions..... 30

2.4 **REVISITING HOBBES'S FOURTH OBJECTION TO THE *MEDITATIONS*..... 34**

2.5 CONCLUSION..... 37

3.0 MECHANICAL EPISTEMOLOGY, MAKER'S KNOWLEDGE, AND *SCIENTIA*..... 38

3.1 INTRODUCTION..... 38

3.2 CAUSAL KNOWLEDGE IN A WORLD OF UNDERDETERMINED APPEARANCES..... 41

3.3 GEOMETRIC CONSTRUCTION AND CAUSAL KNOWLEDGE..... 45

3.3.1 Knowledge of Particular Causes in Geometry..... 48

3.3.2 Knowledge of Universal Causes in Geometry through Definition..... 52

3.4 FIRST PHILOSOPHY AS COMPUTATION AND CONSTRUCTION..... 64

3.5 CONCLUSION: BUT IS CAUSAL KNOWLEDGE *REALLY* AVAILABLE IN NATURAL PHILOSOPHY?..... 73

4.0 HOBBES, ARISTOTLE, AND MIXED MATHEMATICS..... 76

4.1 INTRODUCTION..... 76

4.2 GEOMETRY AND HOBBESIAN OPTICS..... 79

4.2.1 A Case study from Hobbes's Optics in *De homine* 2..... 79

4.2.2 Hobbes's Geometry in *De corpore* Part III..... 83

4.2.3 *De homine* Case Study Revisited..... 88

4.2.4 Hobbes's Optics and the Deductivist Account..... 92

4.3 ARISTOTLE AND HOBBES ON MIXED MATHEMATICS..... 94

4.3.1 Aristotle on Mixed Mathematics 95

4.3.2 Hobbes and the Aristotelian Mixed Mathematics Tradition 97

4.4 CONCLUSION 101

5.0 HOBBES, BOYLE, AND NATURAL PHILOSOPHY AS "TRUE PHYSICS" 105

5.1 INTRODUCTION 105

5.2 *DE CORPORE* PART IV AS MIXED-MATHEMATICAL "TRUE PHYSICS" 108

5.2.1 The Explanation of Sensation in *De corpore* 25.1-2 108

5.2.2 The Explanation of Swelling of the Parts of the Body when Warm in *De corpore* 27.3 115

5.2.3 *De corpore* Part IV Reconsidered 124

5.3 MIXED MATHEMATICS AND *LEVIATHAN AND THE AIRPUMP* 125

5.4 CONCLUSION 132

6.0 HUMAN SCIENCE AND POLITICS 134

6.1 INTRODUCTION 134

6.2 HUMANS CONSIDERED AS NATURAL BODIES 136

6.2.1 *Leviathan* Part I versus Hobbes's Other Works 137

6.2.2 A Complete Account of the Passions 139

6.2.2.1 *Elements of Law* 139

6.2.2.2 Complete Account of the Passions: *De homine* and *Leviathan* 141

6.2.3 Making an "Inference from the Passions" to the State of Nature 145

6.2.3.1 Driving Passions and Humans outside of Society 148

6.2.3.2 How the Driving Passions are Related to One Another 153

6.2.4 Reason and Persons 156

6.3 HUMANS AS CITIZENS 160

6.3.1 Final Causes in the Commonwealth and Not in Geometry 161

6.3.2 The Maker(s) of the Commonwealth versus The Maker in Geometry .. 164

6.3.2.1 Maker's Knowledge for Those Who enter the Covenant? 164

6.3.2.2 The Sovereign as Maker and Politics as Mixed Mathematics 171

BIBLIOGRAPHY 179

LIST OF FIGURES

Figure 1. **Diagram from *De homine* 2** 82

Figure 2. **Diagram from *De corpore* 22.6** 82

PREFACE

My dissertation provides a novel understanding of Thomas Hobbes's philosophy as a unified system. In articulating this interpretation in 6 chapters, I highlight some problems for Descartes's philosophy which Hobbes avoids. Chapter 1 outlines the state of the literature on the unity of Hobbes's philosophy. Chapter 2 argues that Hobbes had a coherent account of the mind and scientific knowledge (*scientia*) in place in the late 1630s and early 1640s. Chapter 3 articulates Hobbes's ideal form of scientific knowledge—maker's knowledge. Chapter 4 argues that the mixed mathematical sciences provided Hobbes with inspiration for thinking about how the various sciences were related to one another. Chapter 5 shows how this system of maker's knowledge and mixed mathematics characterizes Hobbesian natural philosophy, highlighting how this is at play in the Hobbes-Boyle debate. Finally, Chapter 6 argues that this system is even behind the politics of *Leviathan*.

I have acquired many debts through the writing of this dissertation and through my training. My greatest intellectual debt is to Peter Machamer, whose guidance has been invaluable. Peter's comments and criticisms have many times been incisive in ways that I only realized upon later reflection, and his kindness and support of my work have always been unfailing. I also wish to thank Daniel Garber for his helpful feedback on my dissertation work and for many fruitful conversations about Hobbes and other figures. I wish to thank Douglas

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The Department of History and Philosophy of Science at the University of Pittsburgh has been a remarkable place to conduct my work in the history of philosophy and the philosophy of science. I am grateful to have been surrounded by interesting colleagues, in particular Kathryn Tabb, Elizabeth O'Neill, Julia Bursten, Aleta Quinn, Bihui Li, Joseph Milburn, and Peter Distelzweig. My work in the history of philosophy has been shaped by my prior training in religious studies and Greek textual criticism. Here I owe a great debt to Donald Bowdle, John Byron, and David deSilva. It was through Don Bowdle's teaching that I first thought that I might pursue scholarship. I would never have thought about scholarship as a form of service were it not for Don. John Byron showed me how to be both a productive scholar and compassionate mentor; John's encouragement at an early stage of my graduate training helped shape my own conception of myself as a scholar and teacher. Through his guidance of my work on Greek manuscripts, David deSilva exhibited a model for precision and rigor which I have strived to imitate in my own historical and philological work.

My dissertation research was funded by a Fellowship from the Mellon Foundation and the American Council of Learned Societies (the Mellon/ACLS Dissertation Completion Fellowship) and by several Arts and Sciences Fellowships from the University of Pittsburgh. My archival research on the Hobbes Papers at Chatsworth House was supported by a grant from the Wesley Salmon Fund and by travel funding from the Department of History and Philosophy of Science. I also thank the *British Journal for the History of Philosophy* for permission include parts of my forthcoming paper in chapter 2.

Finally, none of my work would have been possible without the encouragement of Shannon Bernard-Adams, my spouse. Beyond our many personal connections, my own work in philosophy of science began in the many conversations that Shannon and I have had regarding methodology in clinical counseling and diagnosis. Shannon is an incredible friend and partner, and words fail to describe my appreciation for and indebtedness to her. I dedicate this dissertation to her.

This dissertation uses the font SPIonic for Greek text.

1.0 INTRODUCTION

1.1 HOBBES AND THE UNITY OF THE SCIENCES

The unity of Hobbes's philosophy has been a perennial topic in Hobbes scholarship. At numerous points in the corpus, Hobbes argues that he has provided a complete and unified system, with connections between first philosophy, geometry, natural philosophy, and politics, what I will hereafter call the Hobbesian sciences. For example, in *De corpore* 6.6 Hobbes links what he calls "our simplest conceptions," such as 'place' and 'motion', which we explicate with definitions when we are working in first philosophy (OL I.62), with generative definitions in geometry, such as the definition of 'line'. These he connects ultimately with considerations in natural philosophy and morality:

> When, therefore, universals and their causes (which are the first principles of knowledge τοῦ διότι) are known, we first have their definitions (which are nothing other than the explications of our simplest conceptions). [...] Next we have their origins or descriptions, as for example that a line is made from the motion of a point, a surface from the motion of a line, one motion from the motion of another and so on. [...]After the consideration of those things which are produced from motion *simpliciter*, there follows the consideration of those things which the motion of one body effects in another body. [...] After physics we come

> to morals, in which the motions of minds are considered, namely desire, aversion, love, benevolence, hope, fear, anger, jealousy, envy, and so on; what the causes of these motions are, and of what things they are causes. And these things are thus to be considered after physics, because their causes are in sense-experience and imagination, which are subjects of the study of physics. That all these things ought to be investigated in the order I have said consists in the fact that physics cannot be understood unless the motion which is in the minutest parts of bodies is known and such motion of the parts [cannot be understood] unless what it is that effects motion in another thing is known, and this [cannot be understood unless what simple motion effects is known. [...] Thus those who study natural philosophy study in vain unless they take their principles of inquiry from geometry; and those who write or lecture about such things and are ignorant of geometry abuse their readers and listeners. (Hobbes 1981, 295-301).

Likewise, in *De corpore* 6.17 Hobbes argues that the order of teaching should coincide with the synthetic order of discovery (*De corpore* 6.12, OL I.77). For the synthetic steps in both, one should begin with first philosophy and then proceed through geometry, natural philosophy and eventually arrive in politics (OL I.77).

At first glance, the most straightforward way in which Hobbes achieves this unity among the Hobbesian sciences is through his corporealist ontology (as argued in Martinich 1999, 276-278). Since Hobbes believes that there are only bodies in the world, all sciences are concerned with various aspects of bodies. On such a picture, the various Hobbesian sciences are unified

because each deals with bodies in motion, from simple bodies such as geometrical lines and circles produced by simple motion to complex, artificial bodies such as commonwealths.

One might attempt to draw support for this corporealist ontological unity among the Hobbesian sciences from the table that follows *Leviathan* chapter IX; the chapter is entitled "Of the Several Subjects of Knowledge" (EW III.71-73). In the table, Hobbes divides all philosophy, which he uses synonymously with 'science', into sciences that consider the consequences of natural bodies and sciences that consider the consequences of political bodies. After several additional divisions of the former, the sciences at the furthest branches of the table include first philosophy, geometry, arithmetic, optics, ethics, and poetry, among others.

However, numerous difficulties arise if one understands Hobbes to be displaying the ontological unity of the sciences with this table, i.e., if one takes the table to show how sciences such as first philosophy, natural philosophy, and politics are related to each other. For example, since sciences such as optics and geometry are each at the furthest extent of the table, one is left without any explanation for why it is legitimate to use geometry in optics, as Hobbes does in the optics of *De homine*. Doing so would require one to cross from one genus on the table into another genus. Furthermore, from the table alone it is unclear why it is appropriate for Hobbes at numerous points to use the conclusions of demonstrations from geometry and first philosophy in natural philosophy. Similar difficulties arise with politics, since the science of the just and unjust is under physics and not politics. As a result, I suggest that we look elsewhere for Hobbes's account of the unity among the Hobbesian sciences and understand the table in *Leviathan* IX as only an outline of subjects to be treated by philosophy.[1] In other words, the table concerns only

[1] Perhaps the table reflects the structure of the *Leviathan* and this explains why the science of the just and unjust is part of natural philosophy, which precedes the generation of the commonwealth, as Edwin Curley suggests (Hobbes 1994b, 49 fn. 4). Such a reading also seems supported by a 17/27 May 1657 letter from François du Verdus to

the subjects of the sciences, as in fact the title of *Leviathan* chapter IX suggests, and as such only divides up the sciences according to the different subjects of scientific inquiry.

1.2 UNIFIED VERSUS DISJOINT SCIENCES

Before sketching my argument for the unity of the Hobbesian sciences, I will discuss the two strands of interpretation that have dominated the literature. The first interpretation, which I will call the deductivist account, has the virtue that it takes Hobbes's claims about unity seriously. However, the deductivist account is not without difficulties. Those who hold the deductivist account argue that Hobbes saw his system as unified because of deductive connections *between* the various inquiries, such as between geometry and natural philosophy and between natural philosophy and politics.

According to the deductivist account, although Hobbes does not provide such explicit deductive connections between the sciences, Hobbes held that such deductions could be supplied. Hobbes the "deductivist" is also a reductionist and held that all claims in disciplines like natural philosophy and human psychology could be reduced to claims in first philosophy, i.e., claims that would describe only simple bodies in motion (esp. Hampton 1986). This attempt to provide unity through ontology and deduction, with or without the further claim of reduction, is a dominant interpretation in the Hobbes literature to this day (e.g., Peters 1967; Watkins 1973; Hampton 1986; Talaska 1988; Schapin & Schaffer 1985; Martinich 2005, 172-174).

Hobbes where he takes the table in *Leviathan* IX as only a reason to ask and encourage Hobbes to publish more in the various subjects listed on it and not as providing anything more significant: "I was recently reading your 'Table of the several subjects of knowledge' in your *Leviathan*: wouldn't you like to give us this entire body of philosophy? If you gave us an outline plan of treatises on architecture, navigation, optics [...]" (Hobbes 1994c, 471-472).

I will call the second interpretation the disjoint account. On this interpretation, Hobbes's natural philosophy is completely disjoined, both conceptually and developmentally, from his politics (e.g., Robertson 1886; Taylor 1938; Warrender 1957). Much of the motivation behind the disjoint account relates to a desire to free Hobbes from what is *prima facie* a case of deriving normative claims relating to the commonwealth in politics from descriptive claims related to human psychology and, ultimately, more general claims in natural philosophy (e.g., see Taylor 1938). However, in its attempts to "rescue" Hobbes from some version of the naturalistic fallacy, the disjoint account runs into difficulty since it fails to take seriously Hobbes's claims about the unity of his philosophy. Furthermore, it neglects that many of Hobbes's contemporaries (e.g., Bramhall) saw his views in natural philosophy as having deep and far-reaching consequences for his politics.[2]

Understanding the unity of the various Hobbesian sciences in terms of *deductive* connections between them has proven difficult, with many interpreters admitting the intractability of such a view but nevertheless claiming that Hobbes held it. Furthermore, the influence of the Taylor-Warrender debate has been pervasive in Hobbes scholarship, and so some have attempted to preserve the deductivist aspects of the unified account without holding that Hobbes's thought that he had deduced *moral* claims in politics from descriptive claims in natural philosophy (cf. Watkins 1973). Others less optimistic about the deductivist aspect of the unified account have attempted to preserve some sort of unity without it. For example, Tom Sorell argues that geometry plays merely an educational role within Hobbes's system (Sorell

[2] I do not intend to address in my dissertation the degree to which or whether Hobbes had his natural philosophy worked out in advance of or simultaneous to his political philosophy (for a brief discussion, see Tuck 1988a). In other words, I do not intend to focus on Hobbes's philosophical development. I focus on how we should understand the various Hobbesian sciences to be related to one another in Hobbes's mature philosophy as represented primarily, but not exclusively, in *Elementa Philosophiae* (*De corpore*, *De homine*, and *De cive*) and the English and Latin editions of *Leviathan*.

1986, 6). However, such a concession weakens the claim that Hobbesian philosophy is unified in some stronger sense than the fact that some disciplines have pedagogical priority over others.

In place of these two extremes in the literature on Hobbes, I contend that Hobbes achieved unity by providing mechanical explanations throughout each of these sciences. For Hobbes, a mechanical explanation traces out a mechanism, which is constituted by bodies at various levels of complexity and their respective causal activities that contribute to a phenomenon. My account denies that Hobbes held that there were deductive connections between sciences, and thus it also denies that Hobbes's project was reductive. However, a unity achieved by mere methodological homogeneity, such as mechanical explanation, would not justify the strong claims Hobbes made about the interrelatedness of the various parts of his system to each other. I show that Hobbes looked to mathematics to explicate this stronger sense of unity. Specifically, I argue that the relationship between "pure" and "mixed" mathematics provided Hobbes with inspiration for thinking about the relationships between geometry, first philosophy, natural philosophy, and politics.

Hobbes himself published work in the mixed mathematics tradition (e.g., his work on optics that Mersenne published in 1644), and he viewed his work in optics as rivaling his work in politics, as he expressed in *A Minute or First Draught of the Optiques* (1646). This tradition typically included optics, harmonics, and mechanics, but I demonstrate that, in two texts somewhat neglected by Hobbes scholars (*De homine* and *Anti-White*), Hobbes innovatively expanded the domain of mixed mathematics to include *all of philosophy*. In mixed mathematical explanations, the Aristotelian rule that each science must have its own principles may be transgressed and causal principles from one science, such as geometry, may be used in another science, such as optics, since one treats a physical body as a mathematical body. I argue that

Hobbes's natural philosophy in *De corpore*, his optics in *De homine* and elsewhere, and his politics in *Leviathan* are treated as mixed mathematics disciplines that relied upon a constructed scientific knowledge. These mathematical constructions provided the person engaged in construction with what I call *maker's knowledge*, an epistemology related to the Early Modern idea that knowledge is power. Most provocatively, on my account Hobbes's politics in the *Leviathan* is more like optics in its method than geometry in that politics, too, involves *mixing* two disciplines—mixing human science from *Leviathan* Part I with politics in Part II.

This novel interpretation of Hobbes's philosophy contributes to three significant, long-standing disputes in the literature. First, my account of the unity of Hobbes's philosophy exposes the source of some of Hobbes's earliest objections to Descartes's philosophy in his Objections to the *Meditations on First Philosophy*. I argue that when Hobbes's Objections are situated in the wider context of his developing views of the early 1640s, it becomes clear that, even if underdeveloped, his criticisms were coherent and, in fact, reflected a radical rejection of the Cartesian intellect with the goal of providing an epistemology amenable to the mechanical philosophy.

Second, I show that Hobbes's debate with Robert Boyle is really about the proper dependence of physics upon geometry—it concerns what Hobbes calls "true physics" in *De homine*. The leading way of understanding this debate in the literature (Shapin and Schaffer's *Leviathan and the Air Pump*, 1985) portrays Hobbes as a naïve "deductivist," and neglects his work in, and views on, the mixed mathematics tradition and his broader concerns about the unity of his philosophy.

Finally, understanding Hobbes's treatment of politics as a mixed mathematical discipline allows me to articulate how Hobbes's human science in Part I of the *Leviathan* relates to his

treatment of the commonwealth in Part II. I argue against the views presented in the literature that Hobbes attempts to offer a deduction (Peters 1967; Talaska 1988; Watkins 1973) or a reduction (Hampton 1986) from Part I of the *Leviathan* to Part II while still holding that human science and politics are integrally related to one another in a way analogous to the relationship between geometry and natural philosophy. My account further militates against the view in the literature that Hobbes's politics developed independently from the rest of his philosophy (Robertson 1886; Sorel 1986; Taylor 1938; Warrender 1957). Articulating the relationship between the first two parts of *Leviathan* allows me to show how Hobbes saw his politics as continuous with his work in first philosophy, geometry, and natural philosophy, and how his politics fits within his larger systematic philosophy.

2.0 THE WAX AND THE MECHANICAL MIND: REEXAMINING HOBBES'S OBJECTIONS TO DESCARTES'S *MEDITATIONS*

2.1 INTRODUCTION

Hobbes's Objections to the *Meditations on First Philosophy* have disappointed many, including Descartes himself. Hobbes appears uncharitable or even incoherent at various points, and Descartes's Replies to him are curt and at times dismissive. For instance, in his Fourth Objection, Hobbes protests that "M. Descartes has not explained how they [imagining and conceiving] differ" (AT VII.178; CSM II.125).[3] In this objection, it seems that Hobbes not only ignores the term Descartes uses in the *Meditations*—Hobbes misquotes the text, using *conceive* (*concipere*) rather than *perceive* (*percipere*)—but also overlooks Descartes's distinction in the Second Meditation between what the imagination reveals about the wax and what can be "perceived by the mind alone" (AT VII.31; CSM II.21). It is no surprise that Descartes replies with such a dismissive tone.

In this chapter, I argue that understanding Hobbes's Objections within the context of his views in the late 1630s and early 1640s makes it clear that his criticisms are not only coherent, but in fact reflect a radical rejection of the Cartesian intellect in order to provide an epistemology

[3] I cite Descartes (1964–) as AT, Descartes (1985) as CSM, Descartes (1991) as CSMK, Hobbes (2005) as EW, Hobbes (1839–45) as OL, and Hobbes (1928) as EL, followed by chapter and article.

amenable to mechanical philosophy. To make this argument, I examine Hobbes's *Elements of Law* (c. 1640) and *Anti-White* (1642–43), manuscript notes for *De corpore* by Hobbes, Robert Payne, and Charles Cavendish[4] from the late 1630s to the early 1640s,[5] and the culmination of those notes in *De corpore* (1655) itself. I do not wish to absolve Hobbes from the sin of unclear exposition. Rather, I argue that Hobbes's broader work provides the complete mechanism for scientific knowledge, and that his underdeveloped claims in the Fourth Objection are best understood as a brief summary of that mechanism. I have structured this chapter around the mechanism found in his broader work, outlined below to show the connections between stages:

Hobbes's Mechanism for Scientific Knowledge

1. **The motions from which scientific knowledge originates:** Motions are "*produced*" by external bodies and are then "*propagated*" through various media to the human body;
2. **The formation of conceptions by motions in the human body**: The motions create images (conceptions) when they continue into the human body and "*rebound*" outward from the brain;
3. **The cognitive activity of analyzing**: The human cognitive power turns its attention toward the conceptions and "*analyzes"* or *"resolves"* them, from particular to general and from complex to simple;[6]
4. **The knowledge (*cognitio*) of simplest conceptions**: The human cognitive power "*apprehends*" the simplest conceptions reached after analysis; and
5. **The cognitive activity of synthesizing ending in scientific knowledge**: The human cognitive power "*compounds*" or "*composes*" these simplest conceptions back together in a synthesis to rebuild complex conceptions.

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[4] Ms. 5297 (National Library of Wales), Chatsworth ms. A10, and Harleian ms. 6083, respectively. Jacquot and Jones (Hobbes 1973) transcribe ms. 5297. I thank His Grace the Duke of Devonshire, the Trustees of the Chatsworth Settlement, and Andrew Peppit and James Towe, the archivists at Chatsworth, for allowing me to examine ms. A10 during my visit to the archives in 2011. Harleian ms. 6083 has been digitized by the British Library and is available at http://www.bl.uk/manuscripts/FullDisplay.aspx?ref=Harley_MS_6083.

[5] Much scholarship has been concerned with Hobbes's intellectual development during this period. For example, Duncan (2005) argues that Hobbes was not a materialist in the 1640s, Shapiro (1973) highlights Hobbes's changing views of the propagation of light in media, and there have been extended debates about the authorship of the so-called "Short Tract" and what could be inferred from it about Hobbes's early thought (see, e.g., Tuck 1988; Raylor 2001; and Zagorin 1993). I show that Hobbes's mechanical account of mind and his epistemology remained consistent from the 1630s and 1640s until its completion in *De corpore*.

[6] The nature of analysis for Hobbes will be discussed in greater detail below.

Although commentators have been interested in Hobbes's Objections,[7] many view them as uncharitable or incoherent. For example, Tom Sorrell argues that Hobbes "seems to miss [Descartes's] point" in his Fourth Objection, claiming that "Hobbes does not see that it is the objectivity of conception rather than the process of conception with which Descartes is concerned."[8] However, as I show, the *objectivity* of conception and the *process* of conception are necessarily simultaneous projects for Hobbes. He cannot address one without the other because, unlike Descartes, who posited a faculty of the intellect in the *Meditations*, Hobbes did not believe that such a faculty was consistent with mechanical philosophy. Conjecturing the existence of the intellect and describing its activity as "perceiving" the nature of the wax was, to Hobbes, positing an uninformative black box.[9]

My argument proceeds in three stages. First, I discuss Descartes's Second Meditation on the nature of the wax alongside Hobbes's Fourth Objection. I show that the crux of their disagreement is not about language, as might appear to be the case, but rather the distinction between *imagining* and *conceiving* spurred by Hobbes's rejection of a faculty psychology. Next, I examine what I call Hobbes's mechanical epistemology, in which we have scientific knowledge (*scientia*) without an intellect. I argue that Hobbes's work outside of the Objections replaces the intellect with conceiving, which is precisely the mechanical activity of the mind that figures prominently in his Fourth Objection, and that Hobbes's mechanical epistemology and philosophical psychology should be understood as providing a mechanism to make scientific

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[7] For example, Alanen (2003, 119); Lennon (1974); Mori (2012).
[8] Sorell (1995, 88). For similar criticisms, see Costa (1983, 544). Curley defends Hobbes's understanding of the Second Meditation but finds Hobbes "at his most dogmatic" in a later Objection (1995, 104; see Duncan 2005, 446–447, for criticism of this latter point).
[9] Clarke (2003, 9; cf. 35ff) views Descartes's appeal to mental faculties in the *Meditations*, compared with his natural-philosophical work on the human body before the *Meditations*, as a non-explanatory stopping point that should be seen as a "provisional halt" of explanation, not as some in-principle limit.

knowledge mechanically intelligible.[10] Finally, I revisit the Fourth Objection and argue that Hobbes's work on conceiving in the late 1630s and early 1640s expands upon the mechanism briefly summarized in the Fourth Objection.

2.2 THE WAX IN THE SECOND MEDITATION AND HOBBES'S OBJECTION

2.2.1 "Tak[ing] off the clothes, as it were": Descartes's Method and the Wax

The wax example provides the final step toward the Second Meditation's goal of clarifying the nature of the mind (Wagner 1995); it demonstrates the ability of the intellect to perceive *independently* of the imagination. It also paves the way for the use of *substance* in the Third Meditation (Curley 1986, 163–164). The meditator concludes from this example that bodies are "perceived ... by the intellect alone" (AT VII.34; CSM II.22), not by the imagination or the senses.

The meditator focuses upon "one particular body," the piece of wax, since perceptions of bodies in general are likely to be confused (AT VII.30; CSM II.20). He notes that when the wax is placed near a fire, there are changes in the features of the wax that are perceived by the senses, but the wax still remains wax. The meditator next takes "away everything which does not belong to the wax" and discovers that *extended*, *flexible*, and *changeable* remain. He then asks whether flexibility and changeability are akin to changing "a square shape to a triangular shape" in the imagination (AT VII.31; CSM II.20). However, the wax has the potential to undergo an

[10] Rather than seeing Hobbes as having supplanted the active intellect with language (cf. Leijenhorst 2001, 94), on my account *conceiving* replaces the active intellect. For more discussion on language replacing the intellect, see Leijenhorst (2007, 97) and Pettit (2008, 29).

"immeasurable number of changes," so there is a qualitative difference between changing a square into a triangle in the imagination and understanding the wax as flexible and changeable. As a result, the mediator's understanding of the wax cannot have come from the limited faculty of the imagination (AT VII.31; CSM II.21).

The meditator next wonders which perception of the nature of the wax is more perfect—that which he knew from his sensory perceptions of it with the imagination or that which resulted when he examined it closely by "tak[ing] the clothes off, as it were, and consider[ing] it naked" (AT VII.32; CSM II.22). He concludes that this closer examination is a more perfect perception of the nature of the wax. This denuding of the idea of the wax, the meditator declares, is done only by the intellect, and so the meditator determines that the "intellect alone" perceives bodies (AT VII.34; CSM II.22).[11]

Little is said in the Second Meditation about the process whereby the meditator is able to "take away everything which does not belong to the wax" (AT VII.31; CSM II.20). Marion (1999, 59–60) suggests that the simple natures in Descartes's unpublished *Rules for the Direction of the Mind* (c. 1628) are at play in the wax example and proposes that the material simple natures *extension*, *shape*, and *movement* lie behind the discovery that what remains is "extended, flexible and changeable" (AT VII.31; CSM II.20). However, *pace* Marion, Descartes's views change significantly between the *Rules* and the *Meditations* on two interrelated fronts, regarding (1) the *method* whereby we examine ideas, and (2) the *status of our ideas* as acquired or innate. The *Meditations'* skepticism about the senses is absent in the

[11] Gassendi criticizes this metaphor in his Objections to the *Meditations* (AT VII.271-272; CSM II.189-190) and later in his Rebuttals (1644/1972, 198-199), arguing that whatever this method may be, "the bare substance ... will always retain its hidden quality" (1644/1972, 198). Similarly, Hobbes holds that we never know *substance*, since just as we have no idea of God, "we do not have an idea of substance" (Ninth Objection; AT VII.185; CSM II.131).

Rules.[12] Descartes argues in Rule XII that the intellect inspects what is present in the imagination and carefully distinguishes "the notions of simple things from those which are composed of them" (AT X.417; CSM I.43). The intellect's role when inspecting these ideas in the imagination is to abstract away particular features (such as color or size) and arrive at simple natures, and "we always abstract something more general from something less general" (Rule XVI; AT X.458; CSM I.69).

Descartes's early method in the *Rules* thus begins with particular ideas received in sensation and proceeds by *abstraction* to simple natures. But this cannot be the method behind the wax example, as is clear from Descartes's skepticism about our ability to perceive the natures of bodies through the imagination. In the *Meditations*, ideas such as *extension* are innate, and the intellect inspects them by a method called *exclusion*.[13] Descartes provides several examples of innate ideas in the Third Meditation: "My understanding of what a thing is, what truth is, and what thought is, seems to derive simply from my own nature" (AT VII.38; CSM II.26). These innate ideas—*truth*, *thought*, and *thing*—are used in the *cogito* (Machamer and McGuire 2009, 179). The method of exclusion draws out implications already contained in innate ideas such as these: in his correspondence with Mersenne, Descartes says that we can "draw out from an innate

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[12] See Garber (1992, 42). Curley (1978, 45) highlights Descartes's lack of concern with engaging the skeptic in the *Rules*.

[13] In a letter to Mesland in May 1644, Descartes argues: "There is a great difference between *abstraction* and *exclusion*" (AT IV.120; CSMK 236). The difference is that from abstraction we can only make negative arguments, whereas we can make positive arguments from exclusion. Here Descartes considers whether the soul can exist without the body. Abstracting the body away from the soul shows only that the idea of soul "does not represent [the soul] ... as being dependent on the body and identified with it" (AT IV.120; CSMK 236). In contrast, exclusion involves drawing out an implication already contained in an innate idea. The idea of soul represents it (positively) as "a substance which can exist even though everything belonging to the body be excluded" (AT IV.120; CSMK 236). The exclusion of extension "can be clearly seen in the nature of the soul" because "one cannot think of a half of a thinking thing" (AT IV.120; CSMK 236).

idea something which was implicitly contained in it but which [we] did not at first notice in it" (June 16, 1641; AT III.383; CSMK 184).[14]

None of these details about the method of *exclusion* are explicit in the wax example. My discussion draws on Descartes's correspondence and compares the *Meditations* with the unpublished *Rules for the Direction of the Mind*. Although the meditator does not refer to an innate idea or the method of exclusion in the wax example, it is clear, given what Descartes says elsewhere, that this is the method he had in mind. However, when he wrote his Fourth objection, Hobbes would have had access only to the metaphor of removing clothing and Descartes's claims about the intellect's ability to "perceive."

2.2.2 Hobbes's Objection: Conceiving versus Perceiving and Reasoning as the "Linking of Names"

As previously mentioned, Hobbes misquotes the wax example by using *conceive* (*concipere*) rather than *perceive* (*percipere*): "I must therefore admit that the nature of this piece of wax is in no way revealed by my imagination, but is conceived [*concipere*] by the mind alone" (AT VII.177; CSM II.125). We shall see that Hobbes's usage of *concipere* is unsurprising given his mechanical account of the mind in the 1630s and 1640s, in which *concipere* is a term of art used to describe the process by which the mind (1) represents external bodies with conceptions, and (2) inspects its conceptions to learn about the natures of the things in the world that cause those conceptions.

[14] Machamer and Adams (forthcoming) discuss the difference between abstraction and exclusion. Garber (1992, 44-49) argues that Descartes gives up the method of the *Rules* and the *Discourse* by time of the *Meditations*.

A prima facie reading of the Fourth Objection has Hobbes advancing *two unrelated claims*. The first is a claim about Descartes's failure to distinguish conceiving from imagining: "[t]here is a great difference between imagining, that is, having an idea, and conceiving in the mind, that is, using a process of reasoning to infer that something exists" (AT VII.178; CSM II.125). The second is a speculative claim about reasoning and the way the mind works that purportedly shows Hobbes's confusion about language. This claim appears to be more of a conjecture than an objection: "[W]hat shall we say if it turns out that reasoning is simply the joining together and linking of names or labels by means of the verb 'is'?" (ibid.). If this is the case, then, Hobbes claims, "inferences in our reasoning tell us nothing at all about the nature of things, but merely tell us about the labels applied to them" (ibid.).

Descartes's Reply shows that he holds this prima facie understanding of Hobbes's Fourth Objection. To the first claim, Descartes replies that he has in fact distinguished between imagining and conceiving in the wax example and also in the Sixth Meditation. To the more speculative claim, Descartes replies that Hobbes "refutes himself," and he wonders how anyone could think that reasoning is merely a linking together of names when it is so obviously a linking together "of the things signified by the names" (AT VII.178; CSM II.126). Descartes claims that it is obviously absurd to think that reasoning simply involves the linking of names, for "[w]ho doubts that a Frenchman and a German can reason about the same things, despite the fact that the words that they think of are completely different?" (AT VII.179; CSM II.126). They can reason about the same things because their ideas, though signified by different names, are about the same things in the world. Descartes thinks Hobbes holds that definitions are merely "arbitrary" and is, as a result, confused: "if [Hobbes] admits that the words signify something, why will he

not allow that our reasoning deals with this something which is signified rather than merely with the words?" (ibid.).[15]

In the next section, I argue that what Descartes treats as two *unrelated claims* actually reflect two *interrelated arguments* advanced by Hobbes. The first is an argument about the process of examining our conceptions, and the second is an argument about how the mind works—starting with the motions caused by external bodies and conceptions caused by those motions and ending with the reasoning in which we engage with the help of names. These two prima facie unrelated claims together constitute Hobbes's unified mechanical epistemology and philosophical psychology.

2.3 A MECHANICAL EPISTEMOLOGY FOR MECHANICAL MINDS

2.3.1 Hobbes's Philosophical Psychology: Stages 1 and 2 of the Mechanism

Hobbes explains the mind's abilities solely in terms of bodies in motion, arguing that those who posit immaterial faculties of the mind are making mere verbal distinctions, similar to those who might claim that there was a difference between "space in the intellect and imaginary space" (*spatium in intellectu et spatium imaginarium*; *Anti-white* IV.1; Hobbes 1973, 126). In this section, I lay out the explanatory scope and power of Hobbes's view that conceptions in our

[15] Descartes understands Hobbes, as many have, to be a definitional *conventionalist*. Leibniz also criticizes Hobbes as a "super-nominalist," claiming that Hobbes made *definitions* as well as *truth* depend upon human will (cf. Leibniz 1969, 128). On such a view, we can define names however we desire, irrespective of what they signify. However, Descartes misunderstands Hobbes's emphasis on language. For Hobbes, inferences in language themselves tell us nothing about things; instead, we must examine the conceptions in the imagination that are signified by the names in the inferences. I criticize the conventionalist interpretation of Hobbes in my paper "Hobbes, Definitions, and Simplest Conceptions" (Forthcoming).

minds are simply motions in the brain caused by bodies outside of us and our bodies' reaction against those motions.

The account of the mind in *Elements of Law* could not be more radical. Hobbes rejects all traditional distinctions between the faculties of the imagination and of the intellect, and he further avoids appealing to any inner sense such as a common sense.[16] Hobbes's psychology has only two "powers of the mind": *cognitive* and *motive*. Hobbes explains the cognitive power thus:

> [T]here be in our minds continually certain images or conceptions of the things without us, insomuch that if a man could be alive, and all the rest of the world annihilated, he should nevertheless retain the image thereof, and of all those things which he had before seen and perceived in it; every man by his own experience knowing that the absence or destruction of things once imagined, doth not cause the absence or destruction of the imagination itself. (EL I.8)[17]

Hobbes's conceptions are images caused by motions from bodies outside of us, which motions "proceed from the actions of the thing itself, whereof it is the conception" (EL I.2). These motions "reboundeth back into the nerves outward, and thence it becometh an apparition without" (EL II.9).[18] In his early notes for *De corpore* (c. 1637), Hobbes likens the mind to a mirror: "The mind of man is a mirror capable of receiving the representation and image of all the

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[16] See Leijenhorst (2007, 96–97, fn. 63–64) for discussion of these aspects in *Leviathan* and *De corpore*.
[17] This is an early version of the annihilation-of-the-world thought experiment, which reappears for a different purpose in *De corpore* 7 (OL I.65-66).
[18] Unlike in *De corpore,* where the heart is responsible for the outward motion in *both* conceptions and passions (e.g., *De corpore* 29.1, OL I.396), in *Elements of Law* the brain alone is responsible for the outward motion that forms the conception that a body is outside of us. In *Elements of Law*, the heart is involved only in the outward motions of the passions and "conception is nothing but motion within the head" (EL VII.1).

world" (ms. 5297; Hobbes 1973, 449).[19] Moreover, Hobbes uses *conception* as synonymous with *idea*—as he does later in *De corpore* I.3 (OL I.4).

Instead of positing separate cognitive faculties, Hobbes distinguishes *sense* and *imagination* by whether or not there is an external object presently causing the motion in the brain as well as according to the strength of the motion; there is no qualitative difference between sense and imagination. In *sensing*, the object is present and the motion from it is strongest (EL II.2), while in *imagining*, the object is absent and the motion is decayed (EL III.1). Likewise, dreams (EW III.3), mental fictions (EW III.4), and memory[20] (EW III.6-7) are all explained by lingering motions that combine in diverse ways.

Hobbes also avoids any appeal to separate cognitive faculties when he explains how we know that color is not a property of bodies. Qualities such as color appear because of our body's reaction as it receives motions from bodies. In correspondence written in 1636, Hobbes explains to William Cavendish (Newcastle) that "color [is] but an effect of that motion in the brain" (Hobbes 1994, 38). Without a faculty of the intellect to judge sensations and determine their veracity, Hobbes argues that it is only through the senses themselves that we can correct deceptions such as thinking that color is a property of bodies:

> And this is the great deception of sense, which also is by sense to be corrected.
>
> For as sense telleth me, when I see directly, that the colour seemeth to be in the

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[19] Malcolm (1996, fns. 49 & 70) dates ms. 5297 to 1642–43, but Rossi (1942) and Pacchi (1965) have suggested earlier dates. Even if these notes were written as late as 1642–43, Hobbes likely began the philosophical psychology as early as 1637: in a letter written in January of that year, Digby refers to Hobbes's work on "conceptions" in his "Logike" (Hobbes 1994, 42), and in a letter written in September of that same year, he begs Hobbes to send him any part of his "Logike" as soon as it is completed (Hobbes 1994, 50). Malcolm speculates that "Logike" refers to Ms. 5297 (Hobbes 1994, 43 fn. 2).

[20] In correspondence from 21/31 October 1634, Hobbes strangely explains why one has a better memory of a friend's face than of one's own face by appealing to the remaining motions that have varying amounts of "force" (Hobbes 1994, 22).

> object; so also sense telleth me, when I see by reflection, that colour is not in the object. (EL II.10)

We are deceived if we take color to be a property of bodies, but when we attend to our experience of things such as mirrors, we are able to see our error. Hobbes's strange argument from seeing a reflection in a mirror goes as follows. An image in a mirror appears to be blue, but we know that "the image of any thing seen by reflection ... is not any thing in or behind the glass" (EL II.6). Since a mirror is blue at one moment and not at another, we infer by attending to this sensory experience that blue is not *in the mirror*, that is, being blue is not part of the mirror's nature. Hobbes thinks this is so clear that "every man may prove [it] to himself" (EL II.6).

This argument would have been unconvincing to anyone who held that vision occurs by means of *species* propagated through media. Indeed, Hobbes articulates a simplified version of the *species* view as his target: "the introduction of species visible and intelligible ... passing to and fro from the object, is worse than any paradox, ... [it is] a plain impossibility" (EL II.4). Hobbes's assertion that anyone who encounters a mirror will understand that color is obviously not a property of objects clearly does not establish the *impossibility* of the *species* view; neither do his other arguments in *Elements of Law*. Rather, we should understand Hobbes as showing the explanatory scope of the mechanical mind hypothesis insofar as it can account for such visual phenomena without any appeal to entities such as *species* that were, in Hobbes's view, not mechanically intelligible.

Anti-White XXVII.19 (1642–43) provides support for understanding this to be Hobbes's strategy. There he emphasizes all that can be explained without any recourse to an incorporeal mover, in this case, the soul:

> [E]very perception is a motion in the parts of an animal's body; these, though they are called 'animal spirits' and 'vital spirits', are nevertheless [themselves] bodies; and the motion is aroused by objects, which are also bodies. So up to now we need to have no recourse to an incorporeal mover. (Hobbes 1973, 326; Hobbes 1976, 331)[21]

Hobbes later repeats this final phrase in *Anti-White* XXVII, when showing that he can also explain the presence and lingering of conceptions *without appeal to an incorporeal mover*. Furthermore, as in *Elements of Law*, Hobbes holds in *Anti-White* that animal motion and the intention to accomplish a goal can also be explained with such a mechanical explanation, without needing to appeal to anything incorporeal (Hobbes 1976, 332). Although undoubtedly unsatisfying to those holding the *species* view, Hobbes viewed the strength of his mechanical hypothesis of the mind as the scope of the phenomena it could explain.

[21] There is also a similar account in *Tractatus Opticus* I (1644).

2.3.2 From the Mechanical Mind to Mechanical Epistemology: Stages 3 and 5 of the Mechanism

2.3.2.1 Conceptions and Language

Some commentators have focused on Hobbes's nominalism.[22] Hobbes is interested in names in his writings from the 1640s onward; indeed, in *Elements of Law* he claims that only names are universal and that universals are found nowhere in nature (EL V.5-6), a view he also endorses in *Anti-White* II.6 (1973, 112). However, names play a more limited role for Hobbes than is generally recognized. In the *Elements of Law* and later works such as *De corpore*, both private marks and public names function *merely* as devices to help us remember the connections we discover among our conceptions when adding and subtracting them in the act of conceiving.[23] In this section, I distinguish this limited role of language from the essential role conceptions play in scientific knowledge.

Hobbes distinguishes between two kinds of knowledge in *Elements of Law*: knowledge of sense and scientific knowledge. Both come from *experience*: knowledge of sense is due to the experiences brought about by objects outside of us, while scientific knowledge arises from "experience men have of proper use of names in language" (EL VI.1). Hobbes further characterizes scientific knowledge as the "knowledge of the truth of propositions" (EW VI.1). Thus far, his epistemology seems wholly dependent upon language, and scientific knowledge seems characterized only by individuals' knowledge of how names are joined in propositions.

[22] For example, Hungerland and Vick (1973; in Hobbes 1981); Jong (1986, 1990); Machamer and Sakellariadis (1989); and Pettit (2008).
[23] See EL V.1. I argue that this is the case in later works, such as *De* corpore, in chapter 3.

This prima facie way of understanding scientific knowledge is identical to how Descartes understood Hobbes's Fourth Objection, as already discussed.

However, as we shall see, Hobbes's analysis shows that scientific knowledge is more than merely knowing how to use names. Marks and names are important only as the means by which we engage in reasoning; they are the means by which we organize our "remembrances" (EL VI.1). Indeed, Hobbes allows for a personal mark to be *any sensible object*, such as a rock left in a certain place to warn of an upcoming danger at sea (EL V.1), and not merely a *verbal* mark or name. Indeed, instead of words, humans could have used different colored rocks as personal marks and then also as public names.

Furthermore, there is no *language* of thought for Hobbes. Instead, the orderly succession of *conceptions*, not names or marks, constitutes the "discourse of the mind" (EL IV.1). In *Anti-White*, Hobbes rejects Thomas White's view that words "reflect the mind":

> "Words," he says on his page 32, "reflect the mind." (We note, by the way, that this is utterly ridiculous, for what resemblance can there be, pray, between a word and the mind? And how is it that, if "words reflect the mind," the languages of all nations are not alike, as their minds are?) (Hobbes 1973, 126; Hobbes 1976, 53)

Here Hobbes rejects the very view of language and the mind, already discussed, that Descartes thrusts upon him in the Replies when Descartes wonders "[w]ho doubts that a Frenchman and a German can reason about the same things, despite the fact that the words that they think of are completely different?" (AT VII.179; CSM II.126). From Hobbes's earliest work in the 1640s, then, conceptions are the vehicles of the mind, and the names that signify conceptions are our vehicles of convenience for use in reasoning.

Hobbes introduces *truth* and *evidence* to clarify scientific knowledge. Scientific knowledge is "evidence of truth, from some beginning or principle of sense" (EL VI.4). Truth is a property of propositions, and the truth of a proposition depends upon whether, in the case of an affirmative proposition, the name in the predicate "comprehendeth" the name in the subject (EL V.10).[24] The truth of the proposition "charity is a virtue" (Hobbes's example) thus depends upon whether the name *virtue* comprehends the name *charity*.[25] Since it does, the proposition is true.

Evidence provides a reason to believe that the conclusion of a syllogism is true. Evidence is about the relationship of a name to a conception:

> [Evidence] is the concomitance of a man's conception with the words that signify such conception in the act of ratiocination. For when a man reasoneth with his lips only, to which the mind suggesteth only the beginning, and followeth not the words of his mouth with the conceptions of his mind ... though he begin his ratiocination with true propositions, and proceed with perfect syllogisms, and thereby make always true conclusions; yet are not his conclusions evident to him, for want of the concomitance of conception with his words. For if the words alone were sufficient, a parrot might be taught as well to know a truth, as to speak it. (EL VI.3)

Examining one's conceptions to be sure that the words used in reasoning signify those conceptions is what distinguishes scientific knowledge from mere knowledge of sense (EL VI.4).

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[24] Hobbes understands one name comprehending another to be a containment relation. In the *Elements of Logick*, Du Moulin connects mathematical containment with relations between subjects and attributes in logic: "that which in the Mathematicks is said, *to containe*, in Logick is said, *to be attributed*" (1624, 122), and he illustrates this logical relationship by appeal to relationships among numbers, such as that "[t]welve containeth six, and six containeth three, therefore twelve containeth three" (1624, 124). Hobbes uses a nearly identical example in *De corpore* 7.9 (OL I.86-87) to talk about how larger numbers are compounded (*componere*) out of smaller ones.

[25] In the discussion that follows, I italicize names and render conceptions in capitals.

Such examination provides evidence that the conclusions of syllogisms are actually true and not accidentally so—the latter being what Hobbes describes in the case of the individual who reasons perfectly well but whose conclusions, like those of a parrot, "are not... evident to him." A parrot can "speak" a true conclusion, but this will be accidental.

We discover that one conception *comprehends* another conception—and thus gain evidence—by finding a genus-species relationship: the genus conception comprehends the species conception. How do we discover this genus-species relationship when only imagistic conceptions are in the mind? We do so by first discovering which more general conceptions constitute a particular conception when they are *compounded* together (*componere*). We do this by calling to mind the image available and then seeing which more general conceptions always co-occur when we inspect that particular conception and resolve (*resolvere*) it into these general conceptions. In later works such as *De corpore*, Hobbes refers to these two activities of resolving and compounding as analysis and synthesis (OL I.61–62) and also as subtracting and adding (OL I.3).

We find these two cognitive activities in the early notes for *De corpore* (c. 1637), where Hobbes claims that the individual left behind after the annihilation of the world would "subtract and compound" conceptions (Hobbes 1973, 449). In *De corpore* 6.2, when we consider the conception MAN, we discover through analysis and synthesis that MAN is "compounded" from the genus conceptions FIGURATE, ANIMATE, and RATIONAL (OL I.59-60), because whenever we resolve MAN through analysis, these genus conceptions arise. We then reconstruct MAN back together in synthesis in our mind. Hobbes's process of mental compounding or adding together is simplistic, something like FIGURATE + ANIMATE + RATIONAL = MAN. Knowing that ANIMATE is part of MAN confirms that the genus conception ANIMATE

comprehends MAN and provides *evidence* of the *truth* of "man is animate." If one discovers that a name used in a proposition does not signify a conception (e.g., an absurdity like *incorporeal substance*), then one knows that that proposition cannot be true.

Names also help us remember necessary connections among conceptions, or what Hobbes refers to as the "necessary coherence" of conceptions. He argues that "the invention of names hath been necessary for the drawing of men out of ignorance, by calling to their remembrance the necessary coherence of one conception to another" (EL V.13). By "necessary coherence," Hobbes does not mean the association of conceptions with one another through constant accidental occurrence. For example, with a limited set of experiences, the conception RED HAIR might become associated with the conception MAN. For Hobbes, this type of association would not be *necessary*, since we can readily find instances of MAN without instances of RED HAIR. Instead, Hobbes's reference to *necessary coherence* means that we discover that there are containment relationships among our conceptions, which we then signify by using names in propositions.

2.3.2.2 The Activity of Philosophizing

Beyond the role that conceptions have in providing evidence, the subject matter of philosophy itself also consists of conceptions and only indirectly *things in the world*. Indeed, in the early notes for *De corpore* (c. 1637), we find that when we reason "we compute nothing but our phantasms or ideas" (Hobbes 1973, 450; cf. OL I.82). In *Anti-White* XXVII.1, Hobbes argues that philosophy should concern only those things that are conceivable, or imaginable (*imaginabile)*, so we will not even offer definitions for things that we cannot imagine, such as *incorporeal substance* (Hobbes 1973, 312). Because philosophy deals only with things that are

imaginable, such as animals and trees, it follows that things of which we cannot have a conception, such as God or angels, are excluded from philosophy.

Given the constraint of conceivability, philosophizing involves examining conceptions in order to learn the natures of the bodies in the world that cause those conceptions. As a result, Hobbes's first philosophy ignores many traditional metaphysical topics, such as the existence and eternality of the soul or the existence of God, since these fall outside of the conceivable.[26] Instead, Hobbesian first philosophy seeks to "understand the beginning of the teaching of nature" (OL I.81) and thus inaugurate a first philosophy that will be useful for the natural philosopher.[27]

We discover a thing's nature by the same mental activity we employ when determining whether a given name comprehends another name. The only difference between the two activities is the extent of the *analysis* that is undergone—how far we descend, as it were, into the conceptual bedrock. As already discussed, to determine whether a given conception comprehends another conception, we must analyze the latter conception in order to determine whether, when it is compounded back together from genus conceptions, it is constituted by the former conception along with others.

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[26] In his Fifth Objection, Hobbes argues that Christians are forbidden from making graven images because "otherwise we might think that we were conceiving of him who is incapable of being conceived" (AT VII.180; CSM II.127). Regarding this passage, Martinich (2002, 54) appeals to *Leviathan* 11 (EW III.92-93) to argue that "[t]he clear thrust of this passage [from *Leviathan*] is that people can conceive of God even if they have no sense experience of him." However, Martinich's claim results from a failure to see that Hobbes uses *conceive* in two distinct ways: first, to discuss the process of forming conceptions, and second, to refer to the process of analyzing and synthesizing in order to learn about a thing's nature or whether it exists (for examples of the first usage, see EL I.8, EL III.4, OL I.3-4, and OL I.21; for examples of the second usage, see EL XI.2, OL I.9, and OL I.68). For Hobbes, we can conceive only *that* there is a God—the second sense of *conceive*—when we look at the world around us and conceive *that there is a cause of all that is*. Duncan highlights that even though Hobbes does not think that we can have an idea of God, Hobbes is nevertheless committed to the existence of immaterial beings, such as angels, in his Objections to the *Meditations* (2005, 444).

[27] In *Anti-White*, the imaginability restriction allows Hobbes to redefine radically being (*ens*) as "everything that has space, or which can be measured as to length, breadth and depth" (Hobbes 1976, 311), so that *ens* and "body" become synonymous.

However, to determine a thing's nature we must *continue this analysis further* until we arrive at the most basic mental constituents out of which all conceptions are composed—what Hobbes calls the "simplest conceptions"—BODY, SPACE, and MOTION. Then we must compound these back together through synthesis to build the original conception out of the simplest conceptions we have discovered. This more involved role for conceptions—in analysis from a complex conception to simplest conceptions and back to the original conception through compounding in synthesis—can be found in nascent form in *Anti-White* and in manuscript notes for *De corpore*. My discussion of this role of conceptions is based on the mature account in the published version of *De corpore* (1655), with reference to the earlier works throughout.

Hobbes argues in *De corpore* 6.4 that the method (*methodus*) used to achieve knowledge of the causes of singular things first requires analysis from the conception of a singular thing down to simplest conceptions and then synthesis from those simplest conceptions back to the conception of that thing (OL I.61). As the following examples illustrate, Hobbes believes that by this method of analysis and synthesis we can know the causes or natures of *all singular things*.

Hobbes provides two examples in *De corpore* 6.4 of how the analysis/synthesis movement works. The first is of the conception SQUARE:

> [L]et any conception or idea of a singular thing be proposed, say a square. The square is resolved [*resolvetur*] into: plane, bounded by a certain number of lines equal to each other, and right angles. Therefore we have these universals or components of every material thing: line, plane (in which a surface is contained), being bounded, angle, rectitude, and equality. If anyone finds the causes or origin of these, he will put them together [*componet*] as the cause [*causam*] of the square. (Hobbes 1981, 293; OL I.61)

The conceptions into which Hobbes resolves SQUARE are geometric conceptions, and the way to find "the causes or origin of these" will require further analysis until one reaches simplest conceptions. For Hobbes, basic definitions in geometry are "explications of our simplest conceptions" (*conceptuum nostrorum simplicissimorum*; Hobbes 1981, 295; OL I.62). Take the conception LINE from the example. Hobbes defines LINE as follows: "a line is made by the motion of a point" (*linea fiat ex motu puncti*; OL I.63). When we have resolved LINE into the parts of its definition, we have then arrived at simplest conceptions: BODY (point), MOTION, and SPACE. To learn the cause of SQUARE we compound (*componere*) these back together.

Hobbes's second example is GOLD. We resolve GOLD into the conceptions SOLID, VISIBLE, and HEAVY (OL I.61). These conceptions will have to be resolved further until we reach simplest conceptions. The conception SOLID (*solidum*) is a geometric conception, and it is caused by the motion of SURFACE (*superficies*) (OL V.153). SURFACE resolves into LINE and MOTION, and after further resolution we reach the simplest conceptions BODY, SPACE, and MOTION. However, the conceptions VISIBLE and HEAVY are not geometric conceptions. Since Hobbes claims that "the causes [*causae*] of all single things are known" (Hobbes 1981, 293; OL I.292) by analysis and synthesis, we should expect to know the causes of VISIBLE and HEAVY as well, but in the next section I question whether Hobbes can claim this about the non-geometric natures of things, such as that the nature of GOLD is to be VISIBLE.[28] Thus, we shall see that in the case of the wax, Hobbes can hold only that we know that its nature is geometric.

[28] Hobbes provides a third example in *De corpore* 6.3 (OL I.60) that I do not discuss.

2.3.2.3 Questioning an Epistemology of Simplest Conceptions

Several questions arise about Hobbes's account of how we have scientific knowledge (*scientia*) of things' natures by analyzing particular conceptions of them down to simplest conceptions and then putting them back together in synthesis. How can we have universal knowledge when we have only images of particular bodies at our disposal? While criticizing Thomas White's definition of place in *Anti-White* IV.2, Hobbes explains what conceptions represent:

> He [White] ought to have said that [i] the imaginary surface caused by the sight of the running water was an image of the water, not as water, but as body [*corporis*], and that [ii] the image therefore represents [*repraesentare*] not that particular water but any water, or air, or body of the same size and shape (Hobbes 1973, 126; Hobbes 1976, 53).

Here Hobbes is concerned with what is represented in the imagination by the conception we have of moving water. The generality of what Hobbes thinks conceptions represent conflicts with his later view that there no universal conceptions (cf. *De corpore* 2.9; OL I.17-18). One way to resolve this conflict is to hold that the only universal knowledge represented by our conceptions is *geometrical*. Indeed, simplest conceptions for Hobbes are all geometric, such as SPACE—so we can have universal knowledge of geometry because each particular conception represents geometric universals.

Hobbes's account of representation in *Anti-White* relies upon the view that there are various conceptions we may have for a bit of water.[29] For example, upon seeing a bit of water and having a conception WATER arise, we may consider the water as something that we can rely upon for quenching thirst, and an analysis of that particular conception may therefore result in the genus conceptions WET, TRANSPARENT, POTABLE, and STILL. When considering that same conception WATER as a surface, the conception WATER would represent BODY generally: not any particular body or bit of water, but "any water, or air, or body of the same size and shape" (*Anti-White* IV.2; Hobbes 1973, 126; Hobbes 1976, 53). As we have seen, we arrive at the conception SURFACE by analyzing the conception WATER and then by continued analysis arrive at the simplest conceptions BODY, MOTION, and SPACE. After putting the conception WATER back together in our mind from these constituent parts, we would know the (geometric) nature of WATER. This synthesis would begin with the most basic form of body, a point, and then consider it in motion. This motion of the point would form a line, and adding motion to that line would form a surface.

Perhaps Hobbes is entitled to hold that any particular conception represents geometric universals, but what is the status of nongeometric genus conceptions reached in analysis, such as WET or POTABLE? How can we know from analysis whether the nature of WATER is to be POTABLE? As already discussed with the gold example, Hobbes *claims* that through analysis and synthesis we can know "the causes [*causae*] of all single things" (OL I.292), but how can we know that these are the causes of WATER (its nature is made up by its causes) when our conception WATER is only an image of a particular bit of water encountered in experience? Given the paucity of furniture in Hobbes's mechanical mind, Hobbes cannot hold that we know

[29] Hobbes claims this in *Elements of Law*: "Seeing there be many conceptions of one and the same thing, and for every several conception we give it a several name." (EL V.5).

that the nature of WATER is to be POTABLE, or that the nature of GOLD is to be VISIBLE. We can examine imagistic conceptions and learn about general geometric properties from them, but we cannot know that the nongeometrical properties we discover in analysis are part of that thing's nature. The natures we can know from having examined *only a single imagistic conception of single bit of that thing* are geometrical, and this is due to our imagistic conceptions representing universal geometric (spatial) properties. Once we discover these universal geometric properties, we name them so that we can remember them.

Nongeometric genus conceptions arrived at by analysis, such as WET or POTABLE, are accidents that are "not common to all bodies" (*De corpore* 8.3; OL I.93), and as such, they are present at some times but not at others. Water will be water whether potable or not. Indeed, discovering whether some property is part of a thing's nature or is, like color, merely due to our bodies' interaction with it, is a substantial part of Hobbesian natural philosophy. This "decision" about the properties of bodies, Hobbes argues, "is not so easy in physics, where the concern is with the causes of sensible phantasms, which present themselves as the very things of which they are the phantasms and deceive many" (Hobbes 1981, 303; OL I.66). The conception we have of WATER appears to be such that POTABLE may seem to be part of the nature of water upon analysis. So we must discover "whether a phantasm is [from] matter, or some natural body, or whether it is some accident of a body" (Hobbes 1981, 305; OL I.67).

We determine whether a phantasm is from an external body or merely an accident of a body (such as our body) by comparing a given idea, say a conception from a single experience of water, with "the properties of matter and accident, which we have already discovered from their definitions by the synthetic method" (Hobbes 1981, 305; OL I.67). When we compare these two ideas, we must see whether the properties in question can be taken away in our mind: "[W]hereas

the idea arises, is destroyed, is increased, is diminished, and is moved at our decision, it is certain that it [the phantasm] is not matter but accident" (Hobbes 1981, 305; OL I.67). After we have analyzed WATER, we discover which properties of WATER are part of its nature by doing exactly this comparison. We learn that we can remove or "destroy" POTABLE from WATER, but we cannot remove its geometric properties and have it still be WATER. It would not be WATER if it were not partly composed by SURFACE, but WATER can be considered as IMPOTABLE and still be WATER. This entire procedure—analysis, synthesis, and comparison of conceptions—is, as I argue in the next section, crucial for understanding Hobbes's Fourth Objection to the *Meditations*. Indeed, we know the nature of the wax by doing what Hobbes says in *De corpore* 6.8, and we can know only that nature of the wax is geometrical.

Finally, why does Hobbes think that we have scientific knowledge of a thing's nature only when we analyze from the particular conception to simplest conceptions and then compound from simplest conceptions through synthesis? What is it about the activity of engaging in analysis and synthesis that provides *scientia*? I suggest that for Hobbes, scientific knowledge is possible only on this model because it is mechanically intelligible; Hobbes's method for scientific knowledge is trustworthy because *each step in the method has been made mechanically intelligible in terms of bodies in motion*. So humans have scientific knowledge only with the full engagement of this mechanism, and it is in this sense that Hobbes provides a *mechanical epistemology*.

I have discussed each of the elements of the scientific knowledge mechanism with the exception of stage 4—that the human cognitive power "*apprehends*" the simplest conceptions reached after analysis. Hobbes emphasizes the importance of the *entire mechanism* for the possession of scientific knowledge, and we shall see in the next section that this is the key point

of difference between Hobbes and Descartes in the Fourth Objection and Descartes's Reply. Regarding stage 4, our apprehension of the simplest conceptions BODY, MOTION, and SPACE is not in itself scientific knowledge. Instead, our apprehension of simplest conceptions has the same epistemic status as sensory experience; whereas we have *scientia* when we apply analysis and synthesis to a particular conception, we have only *cognitio* of simplest conceptions considered in isolation.[30] I emphasize this aspect of stage 4 as further support for my claim that for Hobbes, *scientific knowledge is acquired only by the engagement of this entire mechanism*. Merely apprehending simplest conceptions would be insufficient.

2.4 REVISITING HOBBES'S FOURTH OBJECTION TO THE *MEDITATIONS*

Descartes's quick dismissal of Hobbes's Fourth Objection shows that he misunderstands Hobbes's terse objections. In their 1641 exchange, Descartes takes the Fourth Objection to consist of two unrelated and poorly defended claims, as already noted: first, a claim that Descartes fails to distinguish conceiving from imagining; and second, a speculative claim about reasoning and the way the mind works that shows Hobbes's confusion about language. However, if we consider these two claims in light of the mechanical epistemology and philosophical psychology Hobbes develops in his other work, we can see not only that the two claims are related to each other, but also that taken together, they constitute Hobbes's strongest objection to the Cartesian view of scientific knowledge and the mind. Hobbes should certainly have

[30] See *De corpore* 6.4 (OL I.61). Hobbes uses *cognoscere* to describe apprehension of simplest conceptions and contrasts it with *scire* to describe knowledge of the "causes of things" acquired by analysis and synthesis. The Molesworth translation (EW I.68) and the most recent translation of Part I of *De corpore* (Hobbes 1981, 292-293) obscure this distinction between *cognoscere* and *scire* by translating both as "know/known".

articulated and defended these claims better, but given the broad range of Hobbes's works at our disposal, we must reject Descartes's dim view of Hobbes's Fourth Objection.

Hobbes's claim that Descartes fails to distinguish between conceiving and imagination should be understood in light of Hobbes's account of the activity of the mind as *conceiving*. As we have seen, Hobbes uses *conceiving* to describe both the formation of conceptions by the mind and the cognitive power's inspection of those conceptions to learn about the nature of the things in the world that cause them. The following comment from Hobbes's Fourth Objection, which Descartes completely ignores in his Reply, now makes sense: "Even the Peripatetics of classical times taught clearly enough that a substance is not perceived by the senses but is inferred by reasoning" (AT VII.178, CSM II.125). Descartes obviously does not think that the wax's nature is "perceived by the senses," but we should understand Hobbes's point to be that it is an illegitimate short-cut—the postulation of an uninformative black box—when Descartes posits the existence of the intellect and describes its activity by saying that it "perceives" the nature of the wax.

Hobbesian scientific knowledge of a thing's nature requires that, rather than relying on a posited intellect, a correct process of reasoning must be undertaken. So when Hobbes claims that Descartes "has not explained how they [imagining and conceiving] differ," he means that Descartes has drawn a distinction in name only, without providing any of the entities or activities that make up the mechanism of conceiving. For Hobbes, positing the existence of an intellect and claiming that it "perceives" the natures of things is no better than saying that we simply perceive the natures of things by our senses. By providing a mechanism, Hobbes shows how scientific knowledge is *mechanically intelligible*, something for which the intellect posited by Descartes is too impoverished.

Furthermore, we now see the shortcomings of Descartes's Reply to Hobbes's Fourth Objection. When Hobbes says "inferences in our reasoning tell us nothing at all about the nature of things, but merely tell us about the labels applied to them" (AT VII.178; CSM II.125), he means that simply examining our inferences in language is worthless. Names are merely tools of convenience that we use to remember what we have discovered through analysis and synthesis. Names by themselves tell us nothing about things in the world. To know a thing's nature, we must inspect the conceptions to which our names refer and then engage in analysis and synthesis.

It would be correct to view Hobbes's second claim in the Fourth Objection as merely speculative if we did not have the full mechanism in his other works. It is understandable that Descartes finds the claim farfetched and thinks that absurdity follows from what he takes to be Hobbes' argument: "[W]hen he concludes that the mind is a motion he might as well conclude that the earth is the sky, or anything else he likes" (AT VII.179; CSM II.126). But what appears to be a speculative account in Hobbes's Fourth Objection is a brief summary of the main points of the complete mechanism that Hobbes develops in his work from the late 1630s and early 1640s, coming to completion in *De corpore*. The connection of the mind to the outside world in terms of motions produced by external bodies is missing from the mechanism summary in Hobbes' Fourth Objection, but as we have seen, it figures prominently in his other work. While we may excuse Descartes for his flippant rejection of what appears to be a speculative conjecture, the broader context shows that Hobbes is in fact criticizing Descartes's faculty psychology and epistemology as unintelligible to mechanical philosophy.

2.5 CONCLUSION

In this chapter, I have argued that we must examine the 1641 exchange between Hobbes and Descartes within the broader context of Hobbes's work in the late 1630s and early 1640s and the fruition of that work in *De corpore*. Descartes's curt Replies to Hobbes are understandable, but to appreciate what Hobbes says in the brief Objections, we must consider Hobbes's general project at the time by taking his other work into account. I have argued that we must understand Hobbes's Fourth Objection as part of his broader program, both his rejection of the traditional faculty psychology that Descartes accepts and his endeavor to develop a mechanical epistemology and philosophical psychology that will together provide a mechanism for scientific knowledge and make it mechanically intelligible.

3.0 MECHANICAL EPISTEMOLOGY, MAKER'S KNOWLEDGE, AND *SCIENTIA*

> Therefore Philosophy, the daughter of your mind and the whole world, is in you yourself; perhaps not yet fashioned, but similar to the world, her creator, formless, as it was in the beginning. Therefore you must do what those who make statues do, who, carving out the unnecessary parts, do not make the likeness but discover it. Or imitate the creation [*Vel imitare creationem*]. If you are going to pay serious attention to philosophy, let your reason hover over the confused abyss of your thoughts and experiences. The confused things must be shaken violently, distinguished, and ordered, having been marked with their own names, that is, in method [*methodo*] it must be according to the creation of things themselves."
> *De corpore*, *Ad Lectorem* (Hobbes 1655, OL I)

3.1 INTRODUCTION

Despite numerous criticisms of Aristotelian philosophy, Hobbes agrees with Aristotle that to have scientific knowledge (ἐπιστήμη) one must have causal knowledge.[31] Hobbes often uses the term *scientia* or one of its cognates to designate scientific knowledge and distinguish it from *cognitio*. However, on Hobbes's account, instead of having a capacity like νοῦς provide the premises for scientific demonstrations, causal knowledge about a given phenomenon is available only to those whose "method resembles that of the creation," as in epigraph above.[32] I call this

[31] For example, OL 1.59; OL 1.72-73; OL 4.42; OL 5.156.

[32] At first glance, there is some tension between Hobbes's resistance to a faculty psychology, already discussed in chapter 2, and references that Hobbes makes to the "natural light" (*lumen naturale*) in mathematical contexts (e.g., OL IV.95, OL IV.395, OL IV.446). In these mathematical contexts, Hobbes appears to countenance the ability to

method "maker's knowledge" to reflect that knowers "make" conceptions in their minds by engaging in synthesis or composition/compounding following analysis. Whereas in chapter 2 I examined how Hobbes's *mechanism* of scientific knowledge provides a mechanically intelligible alternative to the Cartesian intellect, in the present chapter I explore the consequences of this epistemology generally for Hobbes's geometry and first philosophy. In chapter 2, I used the concept *mechanical epistemology* to highlight Hobbes's goal of having a mechanically intelligible epistemological method which rejected positing faculties that were unintelligible in a mechanical philosophy. In chapter 3, I use the concept *maker's knowledge* to refer to the product of that method and to its unique epistemic standing.

Hobbes holds that makers have causal knowledge after constructing geometrical figures and commonwealths, but the natural philosopher does not have such causes available to him:

> Geometry therefore is demonstrable for the lines and figures from which we reason are drawn and described by ourselves and civil philosophy is demonstrable because we make the commonwealth ourselves. But because of natural bodies we know not the construction but seek it from the effects there lies no demonstration of what the causes be we seek for but only of what they may be (EW VII.184).[33]

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grasp a definition without needing to undergo an analysis and synthesis to arrive at that definition, which would further appear to run counter to the account of maker's knowledge that I develop in present chapter. However, in *De corpore* Hobbes discusses how in a demonstration for others one need not provide an analysis since "principles" that begin a demonstration do not require demonstration themselves, but rather only explication (OL I.71). These references to the natural light in mathematical contexts can thus be understood as referring to our ability to automatically grasp certain principles without having to undergo an analysis and synthesis; nevertheless, given his commitment to analysis and synthesis, I argue that Hobbes would not grant to such a grasp the same status as the principles we have arrived at by means of analysis and synthesis. I thank Douglas Jesseph for drawing my attention to these texts within Hobbes's mathematical works.

[33] See also *De homine* 10.5 (OL II.93-94).

However, if access to causal knowledge were limited only to geometry and civil philosophy then the scope of scientific knowledge would be incredibly narrow, so narrow that it would fail to solve the problem which I argue it was designed to solve.[34] I maintain that Hobbes never confined maker's knowledge in this way but instead held that those who construct conceptions in first philosophy also have scientific knowledge.

In this chapter, I argue that Hobbes appeals to maker's knowledge to buttress his natural philosophy against the threat of skepticism about the possibility of scientific knowledge. Maker's knowledge is Hobbes's response to a worry that the actual causes of any given natural phenomenon are vastly underdetermined. Next I explore how maker's knowledge provides causal knowledge in geometrical construction and in the construction of conceptions in first philosophy.[35] In geometry I examine the two steps that for Hobbes are involved in acquiring scientific knowledge: first, knowledge of particular causes from the construction either of a geometrical figure using a straight edge and compass or from a conception in one's mind; and second, knowledge of universal causes from making a definition on the basis of the construction in step one.

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[34] Jesseph (2010, 125) notes this narrow scope for *scientia* and argues that Hobbes's first philosophy would be part of it without providing a reason for why Hobbes could do this on Hobbes's own principles. On my account, those who construct conceptions in first philosophy have maker's knowledge.

[35] I discuss maker's knowledge in Hobbes's natural philosophy in chapter 5 and in Hobbes's political philosophy and the construction of the commonwealth in chapter 6.

3.2 CAUSAL KNOWLEDGE IN A WORLD OF UNDERDETERMINED APPEARANCES

Hobbes defines 'philosophy' in *De corpore* 1.2 by arguing that it takes two paths: "Philosophy is knowledge (*cognitio*) acquired through proper ratiocination of effects or phenomena from conceptions (*ex conceptis*) of their causes or generations, and again of generations which are possible, from known effects" (OL I.2).[36] The first path is the route taken when constructing geometrical figures, conceptions in first philosophy, and commonwealths; the second path is the route taken when working with natural bodies. Although my present focus is upon the first path relating to geometry and first philosophy, since I see underdetermination as Hobbes's motivation for appealing to maker's knowledge in this subsection I will briefly discuss how maker's knowledge is also crucially involved in the second path.

Some have taken Hobbes's epistemology to be concerned with skepticism of knowledge of the external world, a problem similar to the one faced by the reader of Descartes' *Meditations* (e.g., Tuck 1988a, 37-41). However, Hobbes seems unconcerned with such global skepticism for two reasons. First, in *De corpore* 7 Hobbes begins first philosophy with his example of the man who remained after the annihilation of the world (OL I.81ff; more on this thought experiment below), but implicit in this account is that the world which caused the conceptions remaining in the man's mind *did exist* (Sorell 1995, 92). Hobbes never questions the existence of such a world. For example, in his discussion of sensation in *De corpore* 25, he assumes that sensation is caused by external bodies; the issue that concerns him is what can be known about the causal

[36] Hobbes provides slightly, but not significantly different definitions at *De corpore* 6.1 and *De corpore* 25.1. An early definition appears in Robert Payne's notes of *De corpore* (Chatsworth ms. A.10; cf. Hobbes 1973, 463).

relationships in that world given the sort of experiences humans have.[37] Such resources are clearly not available to Descartes' meditator.

Second, in the texts cited by some in support of such global skepticism Hobbes is, in fact, concerned with the possibility of securing scientific knowledge and not the possibility of knowledge more generally. Consider some of the evidence to which Richard Tuck appeals. As support for the claim that Hobbes thought it was impossible to "secure knowledge of the external world," Tuck (1988a, 37) cites a letter from Hobbes to William Cavendish written 29 July/8 August 1636:

> In things that are not demonstrable, which kind is ye greatest part of Naturall Philosophy, as depending vpon the motion of bodies so subtile as they are inuisible, such as are ayre and spirits, the most that can be atteyned vnto is to haue such as opinions, as no certayne experience can confute, and from which can be deduced by lawfull argumentation, no absurdity [...] (Hobbes 1994c, 33).

However, instead of conveying skepticism about knowledge of the external world, *pace* Tuck Hobbes here expresses only that, because the motions of *some* bodies that cause natural phenomena are so small as to avoid observation, merely opinions and not causal knowledge may be reached. Importantly, though 'opinion' characterizes the "greatest part," it does not include *all* of natural philosophy.[38]

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[37] Hobbes assumes this as well in *Anti White* (see Hobbes 1976*,* 79).

[38] I argue in chapters 4 and 5 that this skepticism does not include the optics and much of the natural philosophy that Hobbes provides, but later in this letter to William Cavendish Hobbes does note that optics from Mr. Warner and Mr. Mydorge should not be called demonstrations ("[...] the optiques I know Mr Warner and Mr Mydorge are as able men as any in Europe, but they do not well to call their writings demonstrations, for the grounds and suppositions they vse, so many as concerne light, are vncertayne and many of them not true"; Hobbes 1994c, 33-34). As I argue below, Hobbes is not claiming that all natural philosophy and optics are non-demonstrable, as some in the

In *Tractatus Opticus* II (c. 1640; cf. Alessio 1963),[39] another text which Tuck takes to be a Hobbesian response to global skepticism, Hobbes places three conditions upon what is required in natural philosophy when explaining natural phenomena: first, that "the motions which are supposed or produced be imaginable [*imaginabiles*]"; second, "that through them having been conceded the necessity of the phenomenon may be demonstrated [*demonstretur*]"; and third, that "nothing false can be derived [*deriuari*] from them" (Alessio 1963, 147). Similar to the language of 'opinion' in the 1636 letter above, in *Tractatus Opticus* II the natural philosopher offers a hypothesis or a supposition (*hypothesis sive suppositio*).

The minute size of body parts places a constraint upon what the natural philosopher can know, leading some to claim that for Hobbes there is no scientific knowledge of phenomena. For example, Douglas Jesseph argues that "there is not science of 'sensible appearances' because the specific causal mechanisms that produce such appearances remain hidden from view" (Jesseph 1999, 224). However, a more general issue threatens causal knowledge for Hobbes—the actual causes of any given phenomena, whether caused by visible or invisible bodies, will always be underdetermined.

Underdetermination threatens the possibility of scientific knowledge,[40] as Hobbes notes in *Tractatus Opticus II*:

> […] and since it is not impossible [*non sit impossibile*] that similar phenomena be produced by dissimilar motions; it can be held that from the supposed motion the

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literature have suggested (e.g., Martinich 2005), but rather that only Hobbes's own optics and natural philosophy, and not those of others, are grounded in causal knowledge and are thus demonstrable.

[39] Alessio (1963) is a transcription of Harley ms. 6796, ff. 193-266. Note that Malcolm (1996, 25) argues that this manuscript, commonly referred to as *Tractatus Opticus* II, "must have been completed by 1640," though it is commonly dated 1644.

[40] That Hobbes sees this issue as the threat to the possibility of scientific knowledge marks a departure from the Aristotelian framework. In Aristotle's defense of the possibility of ἐπιστήμη in the *Posterior Analytics*, he defends against the objection that it if all knowledge is demonstrable then it must either be circular or face an infinite regress (*Posterior Analytics* I.3 72b5ff).

effect may be rightly demonstrated, even if nevertheless the supposition [*suppositio*] itself not be true" (Alessio 1963, 147).

Since many possible causes are compatible with any natural phenomenon, we cannot know the actual causes of natural things.[41] This may seem to leave the Hobbesian natural philosopher in a precarious position: on the one hand, to have scientific knowledge he must have knowledge of the causes, but on the other hand, he cannot have knowledge of any of the actual causes of natural phenomena because these are underdetermined. It may seem that the natural philosopher is left to blind conjecture or "good guesses," as A.P. Martinich suggests (2005, 174).

However, such a strong reading of Hobbes's putative skepticism about causal knowledge is unwarranted. Hobbes does place restrictions upon explanations in natural philosophy in *Tractatus Opticus II*, as mentioned already, but the key issue there is to understand what he means for a "motion to be imaginable" (*imaginabiles*) or which generations are "possible" as he says elsewhere in *De corpore* I.2 (OL I.2).[42] I delay full treatment of how Hobbes uses maker's knowledge in natural philosophy until chapter 4, since my goal is to explicate Hobbes's mitigated skepticism and argue that maker's knowledge is Hobbes's answer to underdetermination.

The basic idea, which I develop in subsequent chapters, is as follows. For a motion to be conceivable, which is what I understand Hobbes to mean by 'imaginable', it must be a motion

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[41] Also see *De homine* 10.5 (Hobbes 1658, p. 60; OL II.93); *Decameron Physiologicum* (EW VII.88), *Problemata physica* (Hobbes 1674, p. 38ff; OL V.209), and *Tractatus Opticus (II)* (Hobbes 1644).

[42] See also *De Corpore* 30 (OL I.431) and *Dialogus Physicus de Natura Aeris* (OL IV.247). Horstmann (2001, 492-493) argues that out of a range of possible hypotheses the Hobbesian natural philosopher must select those hypotheses which agree with first philosophy and geometry, and this would greatly restrict the range of options available. However, on Horstmann's account Hobbes simply "reduces" these hypotheses in natural philosophy to geometrical principles (2001, 494), but this misses a key issue—that borrowing geometrical principles, the language I will introduce in chapter 4 on optics and mixed mathematics, and not *reduction* is Hobbes's way of mitigating the threat of underdetermination.

which an individual constructs either in his mind from conceptions or constructs on paper using a compass and a straight edge.[43] Since he is the "maker" of this construction, he has causal knowledge of the motion which he can then use in natural philosophy. Maker's knowledge does not secure the *actual* causes responsible for a particular natural phenomenon. Instead it provides the natural philosopher with *possible* causes that really are conceivable—since they are ones conceived by means of construction—and that are mechanically intelligible.

3.3 GEOMETRIC CONSTRUCTION AND CAUSAL KNOWLEDGE

Why discuss maker's knowledge in geometry before maker's knowledge in first philosophy? After all, Hobbes discusses the latter first in *De corpore*, and it seems reasonable

[43] Douglas Jesseph (2013, 58) discusses two "basic laws" which for Hobbes, he argues, govern motion and which are "demonstrable from the very definitions of the concepts involved"; these are what Jesseph calls the "persistence principle" in *De corpore* 8.19 (OL I.102-103) and the principle of action by contact in *De corpore* 9.7 (OL I.110-111). On Jesseph's view, then, these two principles are prior to explanations in natural philosophy; furthermore, at first glance these two principles seem to be confirmed independently of the criterion of "conceivable" that I discuss in this chapter. Instead, they seem to be demonstrated, as Jesseph argues, from only the "very definitions of the concepts involved." I will not discuss these two principles in detail in this chapter; however, two points are relevant to what I will discuss. First, these two principles depend upon one another—the second principle explicitly depends upon the first, as is evident from Hobbes's citation of the first principle in discussing the second (cf. OL I.110). Second, the way that Hobbes establishes the first principle is not by giving the principle itself and expecting it to be understood by definitions of the concepts. Instead, Hobbes does so by a thought experiment that depends upon the annihilation of the world thought experiment. He asks that we suppose (*supponamus*) that some finite body exists at rest (*quiescere*) and that all the space around that body be understood as a vacuum. Next we consider what would happen if that body began to move; Hobbes claims that since there was nothing in the body that disposed (*disponebat*) it not to be at rest, its movement must be caused by something external. But since we supposed nothing existed outside of this finite body, we cannot makes sense of this body moving at all. The important aspect of this establishment of the principle by supposing an abstracted scenario is that the principle of persistence depends upon the simplest conceptions BODY, SPACE, and MOTION that Hobbes employs. Rather than being "demonstrable from the very definitions," the persistence principle follows directly from consideration of the simplest conceptions established by the annihilation of the world thought experiment, begun in *De corpore* 7 (discussed at length below). For example, Hobbes's claim, in establishing the persistence principle, that there is nothing in the finite body disposing it to not be at rest is a direct consequence of the understanding of the simplest conception of body that he has already established in *De corpore* 8.1.

that the former might be grounded upon the latter.[44] These two issues are interrelated. Hobbes's discussion of the unity of his philosophy in *De corpore* 6.6 makes it seem like geometrical construction actually depends upon conceptions from first philosophy such as 'body' and 'motion' (OL I. 62; Hobbes 1981, 295-301). However, I will argue that such conceptions used in basic geometrical construction, which Hobbes calls "simplest conceptions," are independent from his use of them in first philosophy, thus providing a reason within Hobbes's account for the separation of geometry from first philosophy.[45] These simplest conceptions are known apart from first philosophy and geometry—they are "manifest *per se* [*manifestae per se*]" (OL I.62).

Furthermore, I discuss geometry first because, whereas first philosophy involves both the analysis and synthesis of conceptions, the "true account of geometry is through synthesis":

> For so much as anyone afterwards is an analyst, he was that much before a geometer; nor do the rules of analysis make a geometer, but synthesis [does], beginning from the elements themselves, and continuing to the elements by a logical use of them. For the true account of geometry is through synthesis [*Vera enim traditio geometriae est per synthesin*], by the method Euclid has taught. (OL I.255-256).

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[44] *De corpore* parts II and III are devoted to first philosophy and geometry, respectively. Earlier versions of *De corpore* appear to have had a longer section on *philosophia prima* as Robert Payne's notes on an early draft lists chapter headings beyond what was included in the published version (Payne, ms. A.10, Chatsworth House Archives, fol. 10, verso; for discussion of the authorship of these notes, see Malcolm 2002, 82, 100).

[45] In the present chapter, I focus on Hobbes's account of basic geometrical construction of figures such as circles and triangles in *De corpore* and in *Leviathan* since it is there that he provides his clearest exposition of maker's knowledge. However, his later treatment of geometry in part III of *De corpore* relies upon the construction from first philosophy. For example, Hobbes's treatment of 'endeavor' in *De corpore* 15.2 relies directly upon conceptions constructed in first philosophy (e.g., 'motion', 'space', and 'time'). I will discuss these aspects of his geometry which depend up on first philosophy when I focus on his application of it to optics in chapter 4 and natural philosophy in chapter 5.

Synthesis for Hobbes is "...ratiocination from the first causes of construction [*a causis primis constructionis*] through the middle [causes] continued to the very thing itself" (OL I.254).[46] Synthesis is not only the method in geometry by which geometers discover truths about the natures of figures, but moreover it is the method of demonstration whereby they should teach others (OL I.71). Thus, the "entire method of demonstrating is synthetic" (OL I.71); I delay further discussion of analysis until section 3.4 when I discuss maker's knowledge in first philosophy.

Hobbes places priority upon synthesis because it consists in construction; when one engages in synthesis one has maker's knowledge. Given such a background commitment to maker's knowledge, it should be unsurprising that Hobbes places not only evidentiary weight upon synthesis but also assigns pedagogical priority to it. Since my focus is the relationship of synthesis and analysis to Hobbes's account of maker's knowledge, I leave to the side issues related to the history of analysis/synthesis distinction in mathematics and philosophy, as well as Hobbes's indebtedness to this tradition.[47]

Descartes provides a point of contrast to Hobbes's view of the priority of synthesis over analysis. Descartes discusses this issue in response to Mersenne's request to have written the *Meditations* according to the *more geometrico* (AT VII.128; CSM II.92). Descartes argues that analysis is not only "the best and truest method of instruction," but also that synthesis is merely

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[46] I use the terms 'analysis' and 'synthesis' with the assumption that for Hobbes there is no clear distinction between mathematical and non-mathematical contexts; he understands both in terms of causes and effects. Hobbes does discuss three different types of analysis in *De corpore* 20.6: analysis according to indivisibles, powers of lines, and motions. Hobbes prefers the method of analysis of motions. I do not focus on this distinction, since my interest in analysis and synthesis is on commonalities between mathematics, politics, and first philosophy; in common among all is a simplistic account of analysis as subtracting or resolving and synthesis as adding or compounding, as we find in Hobbes's discussion of adding and subtracting in *Leviathan* 5. See Talaska (1988) for further discussion of analysis.

[47] Jesseph (1991, 224ff) discusses Hobbes's relation to the classical tradition as well as to his contemporaries. Hintikka and Remes (1974) and Otte and Panza (1997) treat the history of analysis/synthesis distinction.

useful as a "follow up to analysis" in geometry and that "it cannot be so conveniently applied to [...] metaphysical subjects" (AT VII.156; CSM II.111).[48] As we shall see, Hobbes holds that the philosopher engages in synthesis not only in geometry but also in first philosophy; it is synthesis following analysis that provides one with the causal knowledge necessary for scientific knowledge.[49]

3.3.1 Knowledge of Particular Causes in Geometry

Hobbes claims that his geometry in *De corpore* and *Six Lessons* is both novel and more useful than previous accounts. It may seem strange to consider Hobbes's work in *De corpore* part III[50] as geometry, given that there he considers topics such as *conatus* and *impetus*, but Hobbes believes that he is doing something different from previous geometrical work. Rather than recapitulating others' work, he says that before proceeding the reader should read his predecessors, such as Euclid, Archimedes, and Appolonius, and then Hobbes will provide something "new and which particularly serves the interests of physics" (OL I.175-176).

Hobbes argues that his geometry is novel because his definitions provide the motions for construction. These definitions give the efficient causes[51] and thus describe the mechanical way in which a body is moved in construction to make a new body (e.g., a line is made from the

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[48] See also Descartes's claim in *Regulae*, Rule 4 that analysis in geometry and algebra are "spontaneous fruits which have sprung up from the innate principles" of the method he hopes to establish (AT X.373; CSM I.17).
[49] Something similar to Hobbesian synthesis is also part of Descartes' early account of method in the *Regulae* (see Rule 5, AT X.379; CSM I.20), but there without any relation to maker's knowledge. Later Descartes claims in a reply to his second objector that analysis was the sole method that he used in the *Meditations* (AT VII.156; CSM II.111), though it is difficult to connect the text of the *Meditations* with his earlier, more detailed account of method in the *Regulae* (Garber 1992, 47). What exactly Descartes' method is later in his career, particularly in the *Principles*, has been the subject of some dispute (e.g., Garber & Cohen 1982; Raftopoulos 2003).
[50] The title of this section is Part Three, Concerning the Reckonings of Motions, and of Magnitudes (*Pars Tertia, De Rationibus Motuum, et Magnitudinum*).
[51] See Jesseph (1999, 203-204) on Hobbes's appeal to efficient causes, and not to formal causes, as a solution to the question of how mathematical demonstration provides causal knowledge.

motion of a point). In the Epistolary Preface to *Six Lessons*, he argues that definitions that begin demonstrations must include a cause or generation of the subject of the definition:

> And where there is place for demonstration if the first principles, that is to say, the definitions, contain not the generation of the subject, there can be nothing demonstrated as it ought to be. And this in the three first definitions of Euclid sufficiently appeareth. For seeing he maketh not nor could make any use of them in his demonstrations they ought not to be numbered among the principles of geometry (EW VII.184).

Hobbes's criticism is that without providing a definition that specifies the mechanical procedure for constructing a figure one cannot have causal knowledge about that kind of figure. His criticism of Euclid's first three definitions is not entirely fair, since the first Hobbesian definition must be that of 'point', which for Hobbes does not provide one with the mechanical procedure for construction either.[52] Generation enters into Hobbes's definitions with 'line', and this certainly is one which he thinks needs to be corrected from Euclid's account (more on 'point' below).

Why does constructing a geometrical figure provide one with knowledge that cannot be acquired from carefully examining the features of a figure one encounters? Hobbes's example of a circle from *De corpore* 1.5 illustrates what he has in mind. If one were to examine a circle one could not, having just encountered this circle, know by "sense" (*sensus*) whether it is a circle (OL I.5). One could, of course, know that it is circular insofar as it *appears* to be a circle, but one

[52] Douglas Jesseph (1993) discusses Hobbes's criticisms of Euclid, noting that Hobbes drew upon Christopher Clavius's edition of Euclid as well as on Clavius's commentary.

could not know whether, in fact, it has all the properties of a circle because one did not draw that particular circle.[53]

However, the person who has *constructed* this circle is in an epistemically privileged situation, for this individual sees the causes as he constructs the figure. Hobbes says that determining all of the properties "from the known generation of the displayed figure, [is] most easy" (*ex cognita figurae propositae generatione, facillime*) (OL I.5). Hobbes's claim may seem to be about whether or not one can correctly identify a given figure as a circle once one already knows the properties of all circles; however, this oversimplifies the issue. One would not be able to make this identification by sense because one would simply not know all of the properties of that particular figure. For example, one would not know whether that figure had been constructed so that all radii were equal because one had not made that figure. One could measure a particular radius, but for Hobbes this would not provide one with knowledge of *all its radii*, which one would have if one had made the circle.[54] Examining circles by sense, regardless of what one knows of circles in general, simply does not provide one with knowledge of all of a given circle's properties. But why is it "most easy" to know the properties if one constructed it? Hobbes makes a stronger claim than mere ease of knowing—he argues that it is only through having constructed a circle that all the properties of that circle can be known, and that one could not know all the properties of that particular figure otherwise.[55]

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[53] The Molesworth translator tries to represent this latter sense of knowing something is a circle with 'true circle' (cf. EW I.6). Hobbes's distinction here between sense (*sensus*) and construction is interesting, because the constructive process itself appears to be a kind of experience for Hobbes wherein one sees the causes.

[54] The main thrust of this circle example is that causes must be present to ground the definition within a science of geometry. However, it is unclear how, given the instructions for making a circle, we can be sure in constructing the circle that the line will remain rigid and, as a result, have termini that are actually equidistant throughout the entire motion. Hobbes problematically assumes that this will be the case without argument. I thank Douglas Jesseph for helpful discussion of this point.

[55] See also *De homine* 10.5 (OL II.93-94; Hobbes 1994a, 41-42).

In *Six Lessons*, construction is not only the means by which individuals gain causal knowledge of particular figures, but moreover Hobbes holds that construction is relevant to whether someone would think a circle was *possible*: "But if a man had never seen the generation of a circle by the motion of a compass or other equivalent means, it would have been hard to persuade him that there was any such figure possible […]" (EW VII.205).

It is important to separate two distinct epistemic issues. The issue with knowledge of the properties of a particular circle is *not* related to skepticism about whether actual circles encountered in the world can be distinguished from figures that merely appear circular.[56] Instead, the issue is about how knowledge of the properties of circles is acquired and why assertions about those properties are justified. For Hobbes this can be done only once one has constructed a particular circle, which provides causal knowledge (of that particular figure) that the radii were always equidistant from the center point. Yet, however much this knowledge of given figure would be secure, *scientific* knowledge must go beyond knowledge of the causes of a particular figure that one constructs and extend to the knowledge of *all circles*. To do this on Hobbes's account one must have language and make a definition.

[56] To my knowledge, Hobbes does not address this issue. One way he might have addressed it is to hold that one simply considers bodies that are encountered *as if* they were mathematical bodies and then uses the general mathematical knowledge one already has. Such a way of addressing this issue has a direct analogy in Hobbes's treatment of mathematical bodies such as 'line', which is something that is considered *as if* it is breadthless even though "there is no such thing as a broad length" (EW VII.202; discussed more below).

3.3.2 Knowledge of Universal Causes in Geometry through Definition

Hobbes's nominalism has been the subject of much discussion in the literature.[57] My goal is not to enter into the Hobbes's account of language and universality for its own sake, especially since I have discussed some issues related to language in chapter 2. As a result, I will place to the side historical issues of Hobbes's indebtedness to Ockham or others, as well as discussion of problems that may arise for his nominalism as an account of language.[58] Since my goal is to explicate Hobbes's account of *scientia*, I will focus on the universality needed for scientific knowledge and highlight a lacuna in the literature: the connection between Hobbes's nominalism and maker's knowledge. This lacuna has resulted in most commentators holding that for Hobbes *language does all the work in providing one with universal knowledge*. By focusing on his account of "marks," I show that language for Hobbes is a mere memory device designed to make accessible for future use what one has learned by means of construction. Language is a tool to help one retain maker's knowledge, and later to share it with others by using "signs." Before examining this connection, I turn to the relevant details of Hobbes's account of language.

Insofar as scientific knowledge depends upon language and language depends upon society, Hobbesian scientific knowledge is inherently social. Given Hobbes's account of the end (*finis*) or scope (*scopus*) and utility (*utilitas*) of philosophy in *De corpore* 1.6-7 (OL I.6-9) as being for the practical benefit of humankind, this connection between *scientia* and society is unsurprising. Although Hobbes grants that a solitary individual may become a philosopher of

[57] For example, Bernhardt (1985; 1988); Jong (1986; 1990); Hungerland & Vick (1973; 1981); Machamer & Sakellariadis (1989); and Pettit (2008).
[58] For example, Martinich (1981, 414-416) emphasizes Hobbes's indebtedness to the Ockhamite tradition, whereas Hull (2009, 72ff) highlights Hobbes's departures, in many ways radical, from this tradition.

sorts, he distinguishes between being a philosopher in this limited sense and being one who is able to provide *demonstrations*:

> ...a solitary man can be a philosopher without a teacher; Adam could have been one. But teaching, that is, proving (*demonstrare*), requires two people and syllogistic speech (Hobbes 1981, 313; OL I.71).

The distinction between a philosopher like Adam and one who demonstrates relates to the fundamental distinction in Hobbes's account of language—the distinction between marks and signs. Without language one would be unable to remember what one had previously discovered; so in order to be a philosopher, whether the solitary sort like Adam or the demonstrating kind I will discuss in a moment, "some sensible tokens are necessary" (Hobbes 1981, 195; OL I.12). Hobbes calls these sensible tokens "marks" (*notae*), and they help in remembering what one has discovered.

Hobbes uses the example of a triangle in *De corpore* 6.11 and *Leviathan* 4 to illustrate how marks work. If an individual examined a triangle and "discovered that its angles [...] were equal to two right angles" without the use of language, then he would not know "whether or not this property is in another triangle dissimilar to it, or even in the same one viewed in another position" (Hobbes 1981, 311; OL I.70). Without language, each time that individual encountered a triangle, he would have to engage in the same examination. However, Hobbes argues that "[...] this would not be necessary if words were used (of which every single universal denotes [*denotare*] a conception of infinite singular things)" (Hobbes 1981, 311; OL I.70).

Such an account, if this is all Hobbes had provided, would have been disappointing. Indeed, at this point Hobbes seems to have left a significant gap between having *knowledge of a*

particular triangle and having *universal knowledge of all triangles*, for why would one be licensed to claim universal knowledge after having constructed only one figure simply because one uses the mark 'triangle'? Hobbes provides additional details in *Leviathan* 4:

> [...] a man that hath no use of speech at all, […] if he set before his eyes a triangle, and by it two right angles, such as are the corners of a square figure, he may, by meditation, compare and find, that the three angles of that triangle, are equal to those two right angles that stand by it. But if another triangle be shown to him, different in shape from the former, he cannot know, without a new labour, whether the three angles of that also be equal to the same. But he that hath the use of words, when he observes, that such equality was consequent, not to the length of the sides, nor to any other particular thing in his triangle; but only to this, that the sides were straight, and the angles three; and that that was all, for which he named it a triangle; will boldly conclude universally, that such equality of angles is in all triangles whatsoever; and register his invention in these general terms, *every triangle hath its three angles equal to two right angles*. And thus the consequence found in one particular, comes to be registered and remembered, as a universal rule, and discharges our mental reckoning, of time and place, and delivers us from all labour of the mind, saving the first, and makes that which was found true *here*, and *now*, to be true in *all times* and *places* (EW III.22; emphasis original).

The literature has emphasized Hobbes's nominalism, which is essential to understanding his philosophy since he holds that only names are universal (e.g., EW III.21). However, it is

important to recognize that marks function only as memory aids.[59] I wish to draw attention to what takes place between the particular knowledge this individual acquires and the universal knowledge that is "registered and remembered" in the mark 'triangle'—this is geometric construction.

In construction one separates the essential (i.e., the definitional parts) from the accidental, e.g., in the case above where the individual recognizes that the length of the triangle's sides is irrelevant, and thus acquires universal knowledge to which one can attach a mark. In other words, it is construction that provides something universal to which a mark can be connected. Discovering the universal requires that one be active and not a mere passive receptor. This is why Hobbes describes the method of construction as he does in the note to the reader of *De corpore*, which is the epigraph to this chapter: "The confused things must be shaken violently, distinguished, and ordered, having been marked with their own names, that is, in method it must be according to the creation of things themselves" (OL I). Without language in place, of course, that universal knowledge (at the level of conceptions) would be lost. However, the preparatory work is at the level of the construction of the conception, which is then given a mark.

I suggest that Hobbes offers construction in geometry and the resulting maker's knowledge from it as a mechanical alternative to the active intellect that he rejects from his Scholastic contemporaries and as an alternative to the Cartesian intellect, discussed already in chapter 2.[60] Before one even applies a mark, one moves from knowledge of a single figure to

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[59] Thus marks are merely a sort of short hand to help one remember what one has discovered. For example, elsewhere Hobbes argues that a universal name such as 'rectangle' is merely used for sake of brevity to stand for 'equilateral', 'quadrilateral', and 'rectangular' (OL I.75).

[60] See Leijenhorst (2002, 94) for discussion of Hobbes's rejection of the active intellect as a human faculty. On Leijenhort's account, it is "language [which] takes over the role of the scholastic active intellect" (2002, 94); however, this neglects the centrality of construction as that which provides something for the maker to remember by use of language. My account thus seeks to emphasize the centrality of making within Hobbes's account of universality and language.

universal knowledge of that type of figure by actively constructing it; one remembers what one discovered by using a mark. It is important to note that Hobbes's example above from *De corpore* 6.11 and *Leviathan* 4 is not one in which someone draws a triangle with a straight edge and compass. Rather, an individual is presented with a triangle and, without the use of speech, "meditates" upon the figure and determines the relationship of its angles to two right angles (EW III.22).[61] This happens by a combination of analysis and synthesis when one is working with the conception TRIANGLE, the same method that was discussed in chapter 2. One analyzes TRIANGE into, say, the conceptions '2 INCH SIDES', 'EQUAL SIDES', 'TWO RIGHT ANGLES', and 'THREE ANGLES'. When composing these conceptions together in synthesis, Hobbes claims that one "observes" that the length of the sides is not essential since one may combine the other conceptions by also having the sides be 3 inches long.

How might one "observe" this and other things about the conception TRIANGLE? As already discussed in chapter 2, Hobbesian conceptions are all images, so one is comparing images when engaging in this mental observing. One learns the "universal rule" that "*every triangle hath its three angles equal to two right angles*" by comparing the imagistic conception one has of THREE ANGLES, when the other conceptions that make up the nature of TRIANGLE have been abstracted away, with the imagistic conception one has of TWO RIGHT ANGLES. Comparing these two imagistic conceptions will show them to be equivalent; this discovery at the conceptual level will be remembered with the theorem in language so that one need not do this mental comparison of the conceptions ever again.

[61] I discuss Hobbes's use of 'meditate' in more detail in Adams (forthcoming).

It does not matter for Hobbes whether a geometrical figure is drawn or whether it is constructed in the geometer's mind by combining conceptions together.[62] Both are instances of construction and both provide maker's knowledge. One might also construct a particular triangle by putting a point in motion to draw lines with a straight edge and a compass. This sort of constructive activity, whether drawing or moving conceptions around by resolving them and compounding them, as a mechanical alternative to the intellect, provides the maker with knowledge of what is essential and allows him to discard what is merely accidental. It gives universal causal knowledge. Importantly, one does not differentiate the essential from the accidental by constructing multiple triangles and seeing what remains constant through these various instantiations, for Hobbes notes in the passage above that it is "the consequence found in one particular, [which] comes to be registered and remembered, as a universal rule." Although he provides no further details on how this happens, I suggest that on his account it is by the active construction in analysis and synthesis that one finds this consequence, "observes" the essential, and discards the accidental.

This view that construction or making provides one with what *seem* to be universal conceptions that are merely tagged, as it were, with a mark (or a sign; more on this below) may seem to run directly contrary to Hobbes's claim that only *names* and not ideas, conceptions, or phantasms are universal (*De corpore* 2.9, EW I.19-20; OL I.17-18). I must emphasize that construction does not supply one with a single universal conception of TRIANGLE;[63] rather, it shows the maker that the composite conception TRIANGLE is necessarily composed of the simpler conceptions THREE ANGLES, EQUAL, and TWO RIGHT ANGLES. The mark *triangle* then is a reminder of these necessary connections for future use. The maker observes

[62] This point will become relevant in my discussion of first philosophy below.
[63] See Jesseph (1999, 207-208) for further discussion of universal conceptions.

this necessary connection at the pre-linguistic level—the conceptual level—and thus the mark *triangle* is merely a placeholder for the connections that he discovers through construction. Hobbes's account of defining is mechanical as well. One defines *square* by adding together the marks *quadrilateral*, *equilateral*, and *rectangular*. As a result, the Hobbes says that definitions come before the defined names (OL I.75).

Hobbes does not think that natural philosophy can make progress by remaining at the level of personal memorial marks that philosophers create to help themselves remember their discoveries. There would be no progress in such a case since each person's discoveries would be lost at their death (OL I.12). Thus, signs function as public marks which are shared among speakers: "[…] if the same tokens or marks are common to many and the ones which are invented by one man have been handed down to others, then scientific knowledge [*scientia*] is able to increase in usefulness for the entire human race" (Hobbes 1981, 195; OL I.12). Using signs allows for the increase of scientific knowledge not only because what individuals discover is combined and better developed, but it also makes one's definitions open to correction and adjustment as new information is learned.[64]

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[64] A.P. Martinich (e.g., 2005) argues that Hobbes's account of definition is conventionalist, according to which a definition is arbitrary, i.e., up to the will of the one making a definition, and thus not open for correction or revision. Hobbes's discussion of the "properties of a definition" in *De corpore* 6.14, which Martinich takes to support his conventionalist interpretation (personal correspondence, April 2010), may seem to lend support to this account when Hobbes notes that "[…] it is not necessary to quarrel over whether a definition is to be admitted or not. For, since only the issue between a teacher and a pupil matters, if the pupil understands all the parts resolved in the definition of a thing defined and still does not want to accept the definition, all argument is then already at an end, for it is the same as if he did not want to learn" (Hobbes 1981, 319; OL I.74). This might make it seem there cannot be any dispute between two individuals about a definition; however, notice that Hobbes's condition about the impossibility of a dispute is that the pupil must *understand* all of the parts of the definition. If the student does not understand the parts, Hobbes continues, then the definition is "[…] without argument, unsuitable, because the nature of definition consists in this: that it produces a clear idea of a thing" (Hobbes 1981, 321; OL I.75). A definition of the latter sort would be open to revision and clarification. Since understanding a definition requires that one understand its constituent parts, ultimately traceable back to "simplest conceptions" such as 'body' (discussed below),the only reason a student would not understand a definition is if it did not correctly connect conceptions. For example, the attentive student would properly dispute any definition given for 'round quadrangle' or 'immaterial substance' because for these we "conceive nothing but the sound" (cf. EW III.32).

Hobbes provides several paradigm constructive definitions in *De corpore* 6. For example, he defines a line as follows: "a line is made by the motion of a point" (*linea fiat ex motu puncti*) (EW I.70, OL I.63). A notable difference between this definition of a line and the one Euclid provides, which Hobbes criticizes in *Six Lessons* (EW VII.202), is that Hobbes includes 'motion' in the definition.[65] Hobbes takes Euclid's definition of 'line' as "a breadthless length" as odd since he wonders why one would say that something has length but not breadth when "there is no such thing as a broad length" (EW VII.202). Hobbes's point seems to be that the Euclidean definition pointlessly adds "without breadth" since the measurement of length does not involve consideration of breadth at all. He says that "one path may be broader than another path, but not one mile than another mile [...]" (EW VII.202). So Hobbes argues that a line is "a body whose length is *considered* without its breadth" (EW VII.202; emphasis added).[66] So when we consider something's length, we do not attend to a physical body's actual breadth but merely to measuring its length.

However, this difficulty that Hobbes expresses with understanding the absurdity of 'breadthless length' has nothing to do with Hobbes's reason for including 'motion' in these definitions. Hobbes later pleads with the reader of *Six Lessons* that motion must be included:

> But I must here put you in mind, that geometry being a science, and all science proceeding from a precognition of causes, the definition of a sphere, and also of a circle, by the generation of it, that is to say, by motion, is better than by the equality of distance from a point within (EW VII.210).

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[65] Hobbes is not original on this idea, as similar definitions are found in Clavius and in Aristotle (cf. Jesseph 1999, 80).
[66] See also Hobbes's discussion of 'line' in *De corpore* 8.12 (EW I.111, OL I.98-99).

Hobbes includes 'motion' because otherwise others would be unable to construct from a definition and, importantly, without this they would not have causal knowledge. Apart from his criticism of Euclid's unclear account of length and breadth, this is precisely his problem with Euclid's definition of 'line', namely, that anyone reading this definition would have no idea how to construct such a figure and thus not have causal knowledge.

Nearly unnoticed in the literature on Hobbes's account of geometrical construction is its dependence on his account of conceptions.[67] Maker's knowledge in the case of geometrical construction does not occur *ex nihilo*.[68] Instead, when humans engage in construction they do so only, as it were, with preexisting materials. In *De corpore* 6.6, Hobbes highlights what he calls "our simplest conceptions":

> When, therefore, universals and their causes (*causis*) (which are the first principles of knowledge τοῦ διότι) are known, we first have their definitions (which are nothing other than the explications of our simplest conceptions [*conceptuum nostrorum simplicissimorum*]) (Hobbes 1981, 295; OL I.62).

Understanding Hobbes's account of simplest conceptions requires distinguishing between Hobbes's uses of the terms 'universal' and 'simple'. To explain this distinction, I must first

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[67] Bird (1996) discusses the simplest conceptions upon which geometrical constructions depend, but he does not deal with their unique epistemic status as the most general of all our conceptions. Adams (forthcoming) highlights the epistemic status of these conceptions which we employ in geometrical constructions, arguing that these simplest conceptions such as 'place' and 'motion' are received in experience and then used in the constructive experience.

[68] The ideal for maker's knowledge is God, as Hobbes alludes in the epigraph to this chapter. Although in his discussion of the Nicene Creed in the appendix to the Latin edition of *Leviathan* (1668), Hobbes places the claim in the mouth of interlocutor B that 'made' in the context of theology means "made by God from nothing" (Hobbes 1994b, 501) caution is warranted for anyone who wants to claim that Hobbes thought God created *ex nihilo* and so humans only imitate, as it were, the creation by using preexisting materials. Hobbes's discussion in *Anti White* XXXIII (1976, 410) of creation urges such caution since he claims that insofar as divine act and deed are like human act and deed "the world must be eternal." This follows from the fact that any "conceivable" act must have both an agent and a patient, i.e., two bodies. Thus, creation *ex nihilo* is inconceivable, and Hobbes argues that it must be dealt with by the "teachings of the Christian Faith" and not philosophy (1976, 410).

highlight two key verbs that Hobbes employs in his account of names: 'comprehend' (*complectere*) and 'compound' (*componere*).[69] As already discussed in chapter 2, one name comprehends another when part of its definition includes the other, and less common names are compounded together to make definitions of names that are more common (discussed more below in the context of first philosophy). The more common a name is the more names it will comprehend. As already discussed, Hobbes holds that only names are universal; there are no other universals either in the mind or in nature. Most names which are used are only more or less common and not universal. For example, Hobbes notes in *De corpore* 2.9 that the name *living creature* is more common than *man*, *horse*, or *lion* because the latter are comprehended by (*complectitur*) or contained in (*continetur*) *living creature* (OL I.18).

The names which signify our simplest conceptions, e.g., the names *place* and *body*, are what Hobbes calls simple names: "What is most common or most universal in each and every genus, I call a simple name" (Hobbes 1981, 213, OL I.21). These simple names, as Hobbes refers to them (OL I.21-22), that signify our simplest conceptions are most universal because they must be used to define all other names. That is, they must be part of the definitions of all other names because all other names are comprehended by them. For example, the simple name *body* will be part of the definition of any name that refers to a conception we possess. The name *body* may not be part of the definition typically given for something (e.g., the definition of 'living creature' mentioned above), but by engaging in analysis the name *body* will be discovered to be a part of any name. The simple name *body* comprehends all other names because only bodies exist.

These names are simple because they are not compounded like other names which are defined by adding together other conceptions (e.g., the name *man* which is compounded from

[69] *Componere* is an important concept for Hobbes from at least 1637 onward; he provides a definition in his early notes to *De corpore* (ms. 5297; Hobbes 1973, 451).

animated, *rational*, and *body*; cf. *De corpore* 2.14, OL I.21-22). In *De corpore* 2.14 (OL I.21-22), as elsewhere, Hobbes uses forms of the verb *componere* to designate the action of compounding simpler names into more complex ones. I take this "compounding" from the simplest conceptions to more complex conceptions to be an act of construction (Hobbes sometimes uses 'ratiocinate' [*ratiocinari*] or 'compute' [*computare*] to describe this activity; cf. *De corpore* I.3, OL I.5). This is part of the activity of conceiving that was discussed already in chapter 2, the other part being analysis.

Following his description of our simplest conceptions in *De corpore* 6.6, Hobbes provides PLACE and MOTION as examples of simplest conceptions. Regarding PLACE, he says that "whoever correctly conceives what a place is [...] must know the definition: that a place is a space which is completely filled or occupied by a body" (Hobbes 1991, 295; OL I.62). The second example is MOTION. Later at *De corpore* 6.13, Hobbes provides a criterion for when such a definition is good; he notes that definitions of such things as PLACE and MOTION are well defined "[...] if clear and perfect ideas or conceptions of the things which they name are aroused in the mind of the hearer by means of the briefest speech that can be made [...]" (Hobbes 1981, 313-315; OL I.71-72).

Anyone who has had any sensory experience will possess these simplest conceptions because these conceptions are ubiquitous in sense experience. In other words, any sensory experience will provide one with these conceptions, and so anyone who has had any experience at all will possess them. In *De corpore* 6.6, Hobbes describes the definitions of these simplest conceptions as "nothing other than the explications of our simplest conceptions [*conceptuum nostrorum simplicissimorum*]" (Hobbes 1981, 295; OL I.62). Since for Hobbes all conceptions are received in sensory experience (or otherwise are combinations of conceptions received in

experience), the definition for PLACE is nothing other than an "unfolding," relying here on the etymology of *explicatio* in *De corpore* 6.6, of the conceptions possessed from any sensory experience.

This understanding of Hobbesian simplest conceptions as ubiquitous receives further support from Hobbes's account of names in *De corpore* 5. One of the ways to determine if propositions are true (*propositiones* [...] *verae sunt*) is to resolve in an analysis the names in the proposition continually (*continuata resolutione*) until we have resolved them to what Hobbes calls the "most simple name" (*ad nomen simplicissimum*) (OL I.55).[70] These names are "most simple" because they are the most universal of all names, and so will be reached at the end of any analysis of any name that properly refers to a conception acquired from sensory experience. Hobbes does not give examples of such names here (though he does earlier in *De corpore* 2.14, as already discussed), but certainly names such as *place*, *motion*, and *body*, which signify our simplest conceptions, would count since they will be the most universal of all names.

When we engage in geometric construction we use these simplest conceptions, such as MOTION. Although maker's knowledge provides us with a special form of knowledge, since we are able to conceive of the causes of what we construct, we are able to engage in such construction only by using these simplest conceptions. Thus, the maker's knowledge we acquire in construction is dependent upon these simple conceptions, since simplest conceptions are principles given to makers from sensory experience.

So a given instance of Hobbesian maker's knowledge in geometrical construction proceeds as follows. A person encounters a constructive definition, such as the definition of a

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[70] This differs from Hobbes's earlier account in *Elements of Law* (EL VI.3). As discussed in chapter 2, Hobbes's account of truth and evidence in *Elements of Law* does not require a full analysis down to simplest conceptions for one to have "evidence" of the truth of a proposition.

line that Hobbes provides: "a line is made by the motion of a point." To construct this figure, he must first possess the simplest conceptions MOTION and BODY, which I have argued he receives from any experience. As he constructs the figure, he sees the causes while putting the point into motion since he goes through the experience of construction.[71] This may appear to involve only the lone individual who engages in the experience of construction and uses marks to preserve what he discovers, but such an individual could not possess scientific knowledge that he can remember and share—to do so he must make a definition which includes the causes and use signs known to others.

3.4 FIRST PHILOSOPHY AS COMPUTATION AND CONSTRUCTION

Like his geometry, Hobbes's first philosophy is entirely concerned with what is useful to natural philosophy. As a result, he ignores many traditional topics in first philosophy, such as the existence and eternality of the soul, the existence of God, and so on. He begins his discussion of first philosophy in *De corpore* by indicating this focus on natural philosophy: "We will understand the beginning of the teaching of nature best (as I have shown above) from privation, i.e., from the feigned removal of the universe" (OL I.81).[72] Unlike in the case of geometry and civil philosophy, Hobbes never explicitly says that we have maker's knowledge in first philosophy. As a result, my argument that he holds this view relies upon examining the close connection he makes between the construction of figures in geometry, where he explicitly holds we have such knowledge, and the construction of conceptions in first philosophy.

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[71] He must also understand how to construct, though Hobbes does not discuss this point.
[72] *Doctrinae naturalis exordium, optime (ut supra ostensum est) a privatione, id est, a ficta universi sublatione, capiemus*. See also the definition in Hobbes's early notes to *De corpore* (ms. 5297; Hobbes 1973, 449).

The solution to this apparent problem of whether maker's knowledge is available in first philosophy lies in what counts as Hobbesian "making." I have been emphasizing that on Hobbes's account of geometry it does not matter whether one constructs a plane figure using a straight edge and compass or one constructs a conception of a plane figure out of simpler conceptions (or signs) in one's mind. In either case, one moves something around, whether an actual point or a conception (or a sign), and one acquires maker's knowledge since one knows the causes of that thing by creating it.[73] The movements of the parts, whether conceptions or actual points, are the causes that one observes. I argue that the same thing occurs in first philosophy. Another point of contact is that in first philosophy, as in geometry, one begins with the simplest conceptions that are received in experience and constructs from them to more complex conceptions, e.g., the conception of accident. As I will argue, in the case of first philosophy these simplest conceptions, such as SPACE and PLACE, are shown to be related to each other through construction.

Hobbes connects the knowledge that is obtained through construction in geometrical contexts with the construction of conceptions more generally in *De corpore* I.3 when providing an example of how the mind computes. Humans have sense and memory in common with animals, as well as experience and prudence, but ratiocination distinguishes humans: "And by ratiocination I understand computation [*computationem*]. To compute truly is to collect the sum of many things added together at once, or when one thing from another subtracted, to know the surplus" (OL I.3). Ratiocination is the activity of the philosopher; whether one engages in analysis (subtraction) or synthesis (addition) one is ratiocinating.

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[73] Here I have in mind the example of the construction of the conception of a triangle discussed in *Leviathan* 4 (EW III.22), discussed already. Other figures, such as the construction of the conception of circle, would be constructed similarly.

Although Hobbes also explains the use of language in terms of computation, humans can compute "without words" (*sine verbis*), as in *De corpore* I.3 (OL I.3). Hobbes imagines someone who sees something in the distance which is barely visible. Even without having imposed words, that individual will have the same idea (*ideam*) as that which he calls *body*. Getting closer, he will have the idea for what he may later call *animate*. Finally he may observe or hear things that give rise to a third idea (*ideam tertiam*) that he may later call *rational* (OL I.3).

When these ideas or conceptions all arise from observing the same thing, Hobbes argues that he will conceive the connection between these ideas, even apart from language:

> […] when the whole thing is seen as one, clearly and distinctly, he conceives that idea is composed from the preceding ones, and also in this way the mind compounds (*componit*) the preceding ideas, in the same order which in speech are compounded (*componuntur*) the singular names *body*, *animal*, *rational*, in one name *body animal rational*, or *Man*. Similarly, from the conceptions of *quadrilateral*, of *equilateral*, of *rectangular*, the conception of square is compounded (*componitur*). Indeed the mind is able to conceive of quadrilateral without the conception of equilateral, and of equilateral without the conception of rectangular, and it can conjoin these singular conceptions into one conception, or one idea of square. (OL I.3-4).

Hobbes's connection between the complex conception signified by *square* and the complex conception signified by *man* may seem unrelated to the issue of whether something similar happens in first philosophy. After all, he provides no discussion of whether this individual acquires causal knowledge by realizing the connection of these conceptions.

Hobbes's focus in this example is on how the mind works by computation, so he is not concerned here with how we acquire causal knowledge of a conception like MAN. It is by adding together these ideas in synthesis that the individual *conceives of the connection of the conceptions*. However, as we have already seen in chapter 2, later in *De corpore* 6.4 he argues that the method (*methodus*) used to achieve knowledge of the causes of singular things is first analysis from the conception of a "singular" thing down to its universal causes and then synthesis from those universal causes back to the conception of that thing (OL I.61). Knowledge of causes enters only through the synthesis of constructing from the causes discovered in analysis back to the particular thing under consideration.

Hobbes provides two examples—SQUARE and GOLD—of how this analysis/synthesis movement works in *De corpore* 6.4, which have already been discussed in chapter 2. Hobbes provides another example at *De corpore* 6.3 where he makes a similar point as he did with GOLD. There Hobbes is discussing analysis and synthesis for a different purpose—he is discussing the Aristotelian distinction between knowing that something is (the ὅτι) and knowing why something is (the διότι). In the case of the διότι, Hobbe argues that "the causes of the parts are better known than the causes of the whole" (Hobbes 1981, 289, OL I.59). Again the example of a "whole" which Hobbes considers is the conception MAN. Hobbes clarifies what he means by 'parts':

> But by "parts" I understand in this place not the parts of the thing itself but the parts of its nature (*naturae*), so that by parts of a man, I do not understand head, shoulders, arms, and so on, but figure, quantity, motion, sensation, reasoning, and similar things, which are accidents which assembled at the same time constitute

the whole man—not his bulk but his nature (*naturam*) (Hobbes 1981, 291, OL I.60).[74]

Like in the GOLD example, these conceptions into which the conception MAN will be resolved are from different genera.[75] For example, whereas QUANTITY and FIGURE are in Hobbes's first philosophy in *De corpore* 12 and MOTION as well in *De corpore* 8.10, SENSATION is in natural philosophy in *De corpore* 25.[76]

Just as geometry discovers the "causes of the parts" that make up geometrical figures by means of construction from simplest conceptions, so first philosophy discovers the "causes of the parts" like FIGURE and QUANTITY through construction from those same simplest conceptions. The same move from particular maker's knowledge to universal maker's knowledge is present in first philosophy as there was in geometry. However, Hobbes discusses first philosophy only in the context of individuals who use language (e.g., the individual remaining after the annihilation of the universe discussed below), so I will not elaborate on the step from particular maker's knowledge to universal maker's knowledge in first philosophy.

Hobbes begins first philosophy in *De corpore* 7 by considering what a man who remained after the annihilation of the universe would have to philosophize about, ratiocinate about or upon what he would impose names (OL I.81). Hobbes argues that all the ideas (*ideae*), or phantasms (*phantasmata*), of the things that this individual had seen or otherwise perceived

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[74] The English version of du Moulin's *Elements of Logick* makes a similar distinction between "formall" and "materiall" parts in Chapter VII, using *compounded* to describe the former: "[t]he formall parts are those whereof the Definition is compounded" (1624, 44). See also Chapter VIII for discussion of definition and compounding (1624, 48ff).

[75] I delay discussion of what consequences this issue of different genera has for the type of explanation Hobbes offers until chapter 4 where I discuss the mixed mathematics tradition and chapter 5 where I discuss in detail Hobbes's explanations, as mixed mathematical explanations, in natural philosophy.

[76] Although 'quantity' and 'figure' are treated within part II on first philosophy, they are part of the final three chapters in that part where Hobbes deals with topics prerequisite to geometry (cf. EW I.202).

would remain for him to philosophize upon: "Therefore, to these he would impose [*imponeret*] names, these he would subtract and compound [*subtraheret et componeret*]" (OL I.82). Hobbes wards off the charge of idealism by arguing that this individual remaining after the destruction of the world would be in a position similar to those in the everyday world, for even when we examine the world around us "[...] we compute [*computamus*] nothing but our phantasms" (OL I.82). Astronomy is a case in point: when we measure motion in astronomy we do not "ascend" into "heaven"; instead "we do so quietly in our museum [*musaeo*] or in the dark" (OL I.82). Although only phantasms are computed, all phantasms are caused by bodies in motion, which are encountered in sensory experience. Since phantasms, or conceptions, are caused by that which is in sensory experience, no conception is signified for names such as *God* (EW III.17).

We will, of course, make use of signs that signify those phantasms, or conceptions, but it is the phantasms that we are really examining and the signs used are simply shorthand for working with them. This is what Hobbes means when he says that we "compute nothing but our phantasms" (OL I.82). Although we may use signs in first philosophy, e.g., the sign *body*, those signs are mere shared memorials that signify the conception BODY. A key difference between this remaining individual and those in the everyday world of experience is that he has only ideas from past experiences. In the remainder of this chapter, I will focus upon SPACE, BODY, PLACE, and MOTION in Hobbes's first philosophy, and I will show that Hobbes constructs from the fundamental conception SPACE to these other conceptions.

Hobbes argues that, regardless of which conception this individual examined from his past experiences, he would have the conception SPACE (*spatium*). This conception would be a mere phantasm (*merum phantasma*) (OL I.82), since it would not, when it was being considered, be caused at that time by an external body because everything would have been annihilated. As a

result, Hobbes calls it "imaginary" (*imaginarium*) space. Hobbes defines space as: "[...] space is the phantasm of an existing thing, so far as it is existing, i.e., when no other accident of a thing is considered except that it appears outside of imagining" (OL I.82).[77] That is, space is the phantasm that arises when considering the conception of any body and when one subtracts away in analysis everything else except that thing appeared as outside of the perceiver. Earlier in *De corpore* 7.2, Hobbes argues that one has this proper conception of space when one considers some particular thing only as "simply that it was outside of the mind" (OL I.82). Hobbes takes this definition to be so manifest (*manifestum*) that it needs no argument.

De corpore 8 departs from the lone individual remaining after the annihilation of the world as Hobbes reintroduces one of the annihilated things: "Let us suppose next that one of the things be put back [*reponi*], or created [*creari*] once more" (OL I.90). Putting something back into the universe is the beginning of a construction—we are *adding* or *compounding* conceptions. We discover two things by putting something back into the universe: first, this thing would have no dependence upon the individual's imagination (*imaginatione*); and second, it would a part of the imaginary space such that it would be coincident and coextended (*coincidat et coextendatur*) with it (OL I.90). Hobbes identifies the resulting conception BODY with what is named *body* (*corpus*) (OL I.91) and provides a definition of *body* that makes use of these two aspects of the thing which has been returned.

Hobbes's account of PLACE is related both to the distinction he makes between imaginary space and the extension, or "real space" (*spatium reale*), of a body in *De corpore* 8.4-5. Unlike imaginary space, Hobbes argues that extension does not depend upon our thinking (*cogitatio*) (OL I.93); instead, the magnitude of a body causes this conception (OL I.93). To

[77] [...] spatium est phantasma rei existentis, quatenus existentis, *id est, nullo alio ejus rei accidente considerato praeterquam quod apparet extra imaginantem.*

further distinguish *place* from extension or "real space," he argues that *place* is the part of imaginary space which is coincident with the magnitude of some body. From this account of *place* we construct the definition of *motion*: "motion is a continuous abandoning of one place and acquiring of another [...]" (OL I.97).

Notice that IMAGINARY SPACE (*spatium imaginarium*) is the fundamental conception in Hobbes's first philosophy from which he constructs more complex conceptions such as BODY, PLACE, and MOTION.[78] Whoever undertakes this construction that begins with the thought experiment in *De corpore* 7 has maker's knowledge because he is compounding or adding. As in the case of geometry and the conception MAN, such constructing eliminates the non-essential components from one's definitions. Construction provides the maker with the nature of the thing being created. This is the reason why Hobbes provides examples that engage this construction following each definition. For example, the way that Hobbes distinguishes PLACE from MAGNITUDE is by having the reader consider what happens when a body is moved; its magnitude is retained (*retinere*) but its place is not (OL I.93), and given this consideration it is obvious that they are different from one another.

How does the person who constructs these definitions in first philosophy possess *causal* knowledge? Of what type of cause does the maker gain knowledge? I suggest that the causal knowledge one gains is like the knowledge one gains of the "cause of the square" that Hobbes discusses at *De corpore* 6.4, discussed already in chapter 2. In the case of the square, one learns

[78] It might seem strange to claim that imaginary space is conceptually fundamental since Hobbes believes it to be caused by bodies in motion. That is, why would Hobbes see this conception as foundational when it is clearly caused by the things that are themselves *ontologically* fundamental, namely, body and motion? I grant that body and motion are Hobbes's ontological fundamentals; however, Hobbes's aim in the annihilation of the world thought experiment is to unearth—to explicate—our simplest conceptions caused by bodies in the world. In other words, within this context Hobbes's view that only bodies in motion exist in the world is an assumption for which he does not argue, and his goal is to show which conceptions are caused by any experience of those bodies. Given that aim, imaginary space emerges as conceptually fundamental, even if not ontologically or causally fundamental.

of its cause by first decomposing it into its constituent causes and then by reconstructing it from those causes. One gains causal knowledge of the whole through gaining knowledge of the parts and reassembling those parts in synthesis. Similarly, in first philosophy one begins at the most basic parts, e.g., imaginary space, and gains causal knowledge by constructing from it.[79]

However, the cause that one learns in first philosophy is not an efficient cause that will enable one to make some particular thing. Hobbes's warning that the *actual* causes of natural things are unavailable still stands, and Hobbes notes that one should not think that bodies in the world have been made in the way in which we compound their conceptions: "[...] let us be warned against thinking that bodies outside the mind are composed [*componi*] in the same way; namely that there is in nature a body [...] which at first has no magnitude whatsoever, and then with the addition of magnitude becomes a quantity [...]" (Hobbes 1981, 215; OL I.22).[80]

Nonetheless it is an efficient cause that one learns when constructing from simpler conceptions in first philosophy. But, unlike in the case of geometry, where one provides a causal definition so that others can construct a given figure of that kind by using the definition, in first philosophy one learns *why a given body causes the conception that it does when one has sensory perception of it*. This provides one with knowledge of that thing's nature (*natura*), and this holds in the case of first philosophy as it does in the case of particular bodies, like a particular man (cf. *De corpore* 6.2, OL I.60, which was already discussed). Since bodies cause all of these conceptions, learning the parts which cause the whole conception that one conceives is learning about the body causing that conception. Although one is not providing causes in one's

[79] I argue in chapter 2 that the annihilation of the world thought experiment replaces such an analysis and as such functions as a shortcut to allow one to descend quickly to the simplest conceptions that would otherwise have been discovered by analysis.

[80] Hobbes's general point in this passage in *De corpore* 2.14 is that, though we can resolve and compound bodies in our minds, we must be careful not to think that bodies in the world are put together in the same manner. One apparent target of the discussion in this article is the doctrine of rarefaction and condensation. I thank Douglas Jesseph for drawing this to my attention.

definitions in first philosophy, one is nevertheless learning causes through construction, and thus one is acquiring maker's knowledge.

This reading is supported by Hobbes's distinction in *De corpore* 6.13 between definitions that contain a cause and those that do not. Hobbes argues that the definition of *motion* is an example of a definition that does not contain a cause: "For even if neither anything moving nor any cause of motion is found in that definition, still the idea of motion will appear clearly enough in the mind when this speech is heard" (Hobbes 1981, 315; OL I.72). Although no cause is provided in this definition, one does *learn the causes of the conception of* MOTION when one mentally moves the conceptions BODY and PLACE together to construct it. This provides one with knowledge of the cause of the conception MOTION which, given its connection to bodies in the world, provides one with maker's knowledge of how bodies in the world behave. So the role of Hobbesian first philosophy is to provide one with *maker's knowledge of the causes of one's conceptions*. Since bodies of the same kind reliably cause the same conceptions, one is actually learning about those bodies by constructing their essential "natures".

3.5 CONCLUSION: BUT IS CAUSAL KNOWLEDGE *REALLY* AVAILABLE IN NATURAL PHILOSOPHY?

The early discussion in this chapter was designed to show that Hobbes did hold that causal knowledge in natural philosophy was partially available. I do not wish to deny the hypothetical character of natural philosophy (cf. Jesseph 199b, 233). Many of the causes posited in natural philosophy will be such that they are imaginable, or as Hobbes elsewhere says "conceivable," and they will result in no absurdity. However, since only bodies exist we can

know that principles from geometry—geometrical causes—are the causes of some natural phenomena. So Hobbes's natural philosophy, as we shall see in chapters 4 and 5, finds itself in the *middle*—to use an appropriate term since I argue that it is a mixed mathematical discipline—between two extremes. It is not accorded the full standard of *scientia* which we accord to geometry, but nevertheless it is not doomed to mere "good guesses" (Martinich 2005, 174).

A brief examination of Hobbes's characterization of Aristotle's *Physics* in Dialogue I of *Examinatio et Emendatio* (1660; OL IV, 42-43) will help draw out the distinction that I am making. In the midst of a discussion of Wallis's account of mathematical demonstration (cf. Wallis 1657), interlocutor B notes that Aristotle held that "to know is to know through the cause" (*juxta id quod solemus dicere Aristotelici,* scire est per causam scire). Interlocutor A, however, interjects that Aristotle's physics does not treat the effect "[...] through a known cause, but on the contrary, sought the cause through known effects" ([...] *per causam cognitam, sed contra, causam quaeri per cognitos effectus*). Interlocutor A continues that Aristotle could not know the actual cause "because similar effects may not always and necessarily have similar causes" (*propterea quod similes effectus non semper et nesseario similes habeant causas*). Since the actual causes of things in the world were not available, Aristotle's physics, instead of "beginning from definitions" (*inicipit a definitionibus*) began "from hypotheses, which may be false" (*ab hypothesibus, quae falsae esse possun*) (OL IV.43).

Hobbes's account of maker's knowledge is designed to remedy this situation in which Aristotelian physics finds itself (to Hobbes's eye, at least). One cannot have a merely hypothetical natural philosophy when the threat of underdetermination looms so large. So we borrow causal principles from geometry or first philosophy in natural-philosophical explanations since these borrowed causes are "possible" or "imaginable." These causes are mechanically

intelligible since we construct them. As we shall see in chapter 4, rather than leave physics in its merely hypothetical state, as Hobbes saw Aristotle's *Physics*, for Hobbes true physics can only be *mixed mathematics*: "[...] physics (I mean true physics) [*vera physica*], that depends on geometry, is usually numbered among the mixed mathematics [*mathematicas mixtas*] (Hobbes 1994a). Hobbes does introduce "suppositions" in natural-philosophical explanations, but these are accompanied with causal principles borrowed from geometry or first philosophy.

4.0 HOBBES, ARISTOTLE, AND MIXED MATHEMATICS

> [...] physics (I mean true physics) [*vera physica*], that depends on geometry, is usually numbered among the mixed mathematics [*mathematicas mixtas*].
> *De homine* 10.5 (Hobbes 1994a)

> [...] all the sciences [*scientiae*] would have been mathematical had not their authors asserted more than they were able to prove; indeed, it is because of the temerity and the ignorance of writers on physics and morals [*Physicorum et moralium*] that geometry and arithmetic are the only mathematical ones.
> *Anti-White* (Hobbes 1976, 24; MS 6566A, f. 5 *verso*)[81]

4.1 INTRODUCTION

When discussing Hobbes's natural philosophy, there is no better place to start than his optics. Among his contemporaries, Hobbes's optics was considered to be the mechanical rival to the account Descartes provides in the *Dioptrique* (1637). Mersenne's inclusion of Hobbes's optical treatise in *Ballistica* (1644) is part of the evidence for this claim.[82] Hobbes's optical work

[81] When citing the Latin text by folio number, I refer to MS fonds Latin 6566A held in the Bibliothèque nationale in Paris (the critical edition of this MS is Hobbes [1973]). Although Hobbes uses *moralis* and *ethica* synonymously in this work (cf. lines 7-8, f. 5 *verso*), I have amended Jones' translation to reflect Hobbes's use of *moralis*.
[82] Marin Mersenne, *Universae geometriae, mixtaque, synopsis et bini refractionem demonstratus tractatus* (Paris, 1644). This text is referred to in the literature as Tractatus Opticus I, and it was reproduced in OL V. See Stroud (1983c, 14ff) for comparison of Tractatus Opticus I with the unpublished Tractatus Opticus II and with Hobbes's

was known to all of key individuals working in 17th century optics, such as Descartes, Hooke, Huygens, Newton, and others.[83] Although Hobbes's 1641 correspondence with Descartes ended with Descartes wanting "to have nothing more to do with him, and, accordingly, to avoid answering him" because he thought that Hobbes was trying to gain reputation at Descartes' expense (AT III.320, CSMK 173), their extended correspondence engaged at length in serious debate about points of disagreement between them, especially related to media in which refraction occurs as well the nature of light (see Letters 29-30 and 32-34 in Hobbes 1994c).

Given his general manner of self-appraisal, we should perhaps find it unsurprising that Hobbes saw his own work in optics as monumental. In typical Hobbesian humility, in *A Minute or First Draught of the Optiques* (1646; hereafter *MDO*) Hobbes lauds his own contributions in optics as so significant that they would constitute the founding of a new science which would rival his work in political philosophy:

> Nor do I fear that the attentive Reader will find, that which I have delivered concerning the Opticques fit to be cast out as Rubbish among the rest; If he do, he will recede from the authority of Experience, which confirms all I have said. Doctrine (though yet it wants polishing) I shall deserve the Reputation of having been the first to lay the ground of two Sciences, this of Opticques, the most

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other optical works. Alessio (Hobbes 1963) transcribes the text of Tractatus Opticus II (Harlean MS 6796, ff. 193-266).

[83] My goal is not to establish the reception and influence of Hobbes's optics. Shapiro's classic article (1973) has done so by tracing the influence of Hobbes's account of refraction and theory of light upon Emmanuel Maignon, Isaac Barrow, Robert Hooke, among others. Skinner (1966) discusses Hobbes's long-standing influence on the continent generally, including discussions of his optics years after the publication of *Tractatus Opticus I*.

curious, and that other of natural Justice, which I have done in my book de Cive, the most profitable of all other (Hobbes 1983c, 622; cf. EW VII.471).[84]

For my purposes, however, Hobbes's optics has special importance for two reasons: first, optics was traditionally viewed as a model example of the mixed, or subordinate, mathematics,[85] which in the present chapter I will argue provided Hobbes with a model for explanations outside of optics;[86] and second, it is in his optics, working within the mixed mathematics tradition, that we see Hobbes providing obvious examples of mixed mathematics explanations.

In this chapter, I lay the foundation for my argument, which will continue in chapters 5 and 6, that Hobbes viewed mixed mathematics as providing the model for explanations not only in disciplines traditionally considered "mixed", such as optics and harmonics, but also the model for explanation in *all of philosophy*. My goal is thus to place Hobbes within the Aristotelian mixed mathematics tradition[87] and later to show how this unfolds in his work in natural philosophy (chapter 5) and politics (chapter 6) by showing how Hobbes greatly expands the purview of mixed mathematics.[88]

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[84] NB: I have modernized some of the spellings in this quotation to give ease of reading. Although he completed it in 1646, Hobbes never published *MDO*, but it was in many ways his most comprehensive work in optics. See discussion by Stroud in Hobbes (1983c).

[85] See, e.g., Keckermann's *Systema compendiosum totius mathematices*: "*Opticam & Musicam Philosophi vocant disciplinas subordinatas* ..." (1661, 30).

[86] For some of Hobbes's predecessors in optics, such as Roger Bacon, optics was the *sine qua non* for *scientia* because of the myriad epistemic issues that depend upon solving its problems (Lindberg 1996, xx). For others, such as Robert Grosseteste, optics was essential to the work of the natural philosopher because studying light allowed one to understand the origin and nature of the universe (Lindberg 1976, 97).

[87] Machamer (1978) places Hobbes and Descartes within this tradition, though his focus is on Galileo. See Biener (2007) for discussion of Descartes and the mixed mathematics tradition.

[88] Although not addressing the mixed mathematics tradition, Leijenhorst (2002) establishes Hobbes's connection with late Aristotelianism, e.g., that locating physics within *prima philosophia* was a live option among Hobbes's predecessors and that, even though Hobbes goes further than others would have in viewing *philosophia prima* as "nothing more than *physica generalis*," his view was still within the "Aristotelian horizon of expectations" (36).

First, I provide a case study of Hobbes's optics from *De homine* 2. This case study leads into a consideration of how understanding explanations in Hobbes's optics as a mixed science explanation avoids difficulties created by viewing Hobbes as having either a deductivist account and or a disjointed account (already discussed in chapter 1). Next I treat Hobbes's most explicit discussions of the mixed mathematics tradition in *De homine* 10.5 and in *Anti-White*. Finally, I consider Hobbes's relation to the Aristotelian mixed mathematics tradition, highlighting Hobbes's significant break with this tradition—that maker's knowledge acquired in construction provides the causal knowledge employed in a mixed mathematics explanation.[89]

4.2 GEOMETRY AND HOBBESIAN OPTICS

4.2.1 A Case study from Hobbes's Optics in *De homine* 2

Hobbes scholars have often neglected the first nine chapters of *De homine* (1658) because they have either considered it as a mere reprise of Hobbes's work elsewhere or as simply irrelevant to Hobbes's philosophy.[90] This neglect may also be due to the fact that it was not translated into English in Molesworth's *English Works*, or by any subsequent translator into

[89] Hobbes calls them mixed mathematics (*mathematicas mixtas*) in *De homine* 10.5 (discussed below), and I have used 'mixed mathematics' to reflect this usage (instead of 'subalternate science' or 'mixed science'). For discussion of the phrase 'mixed mathematics' see Brown (1991), although Brown claims that "[a]fter Bacon the first significant intellectual who used the term 'mixed mathematics' was the eighteenth-century 'geometer' and philosophe Jean d'Alembert (1717-83)" (Brown 1991, 83), thus neglecting Hobbes's use in *De homine* 10.5.

[90] For example, Bernard Gert: "Chapter 1 of *De Homine* contains out-of-date biology. Chapters 2 to 9 are concerned with optics. Since they are irrelevant to Hobbes's moral and political philosophy, they have been omitted" (Hobbes 1994a, 35 fn.). Also, A.P. Martinich: "The first nine chapters [of *De homine*], which are devoted to optics, could easily have been treated in *De Corpore*, and in fact are not appropriate in a section that is supposed to be on topics distinctive to human beings […] So the topics of *De Homine* do not fit neatly into Hobbes's descriptive taxonomies and should have been doled out between natural and civil philosophy. *De Homine* thus became little more than second thoughts about the issues already discussed in the two sections of *Elementa Philosophiae* already published" (1999, 278).

English.[91] Nonetheless, Hobbes viewed *De homine* as deeply connected with his work in *De corpore* (1655) and *De cive* (1642).[92] Not only is it important to take Hobbes at his word on the interrelations among the three books of *Elements of Philosophy*, but importantly for my purposes *De homine* is the only optics text where Hobbes has the geometry from *De corpore* available to him to cite—what I will call borrow—in his explanations (unlike, e.g., the *Tractatus Opticus I* of 1644). Thus, *De homine* is the very place that one should look to learn about Hobbes's views on explanation in sciences such as optics. And finally, since it is the middle book between the two more-frequently discussed texts, it is where one should look for discussions about the transition from natural philosophy in *De corpore* to political philosophy in *De cive*.

In my discussion of his optics, I will focus upon *De homine* 2 where Hobbes addresses the visual line and the perception of motion. Hobbes there explains why an object appears sometimes smaller and other times larger and why that object also appears sometimes one shape and other times different shapes. Relatedly, Hobbes explains why objects sometimes appear in a different location from their actual location. Hobbes holds that no one has been able to explain these phenomena because they have not known that light and color are not accidents of objects; rather, he argues, light and color are our phantasms (*phantasmata nostra esse*; *De homine* 2.1, OL II.7). Having noted that the subject matter of optics is phantasms rather than the objects themselves, Hobbes proceeds to explain the phenomena relating to the appearances of objects.[93]

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[91] *De homine* has been translated into French by Paul-Marie Maurin (Hobbes 1974), as well as into German and Italian. However, discussion of *De homine* has largely been concerned with the influences upon Hobbes's optics (e.g., Prins 1987) and not how the work in *De homine* fits within Hobbes's larger philosophy.

[92] For example, see Hobbes's discussion of the interrelatedness of these three works in his dedicatory epistle to William Cavendish in *De homine* (OL II, *Epistola Dedicatoria*; translated in Hobbes 1994a, 35-36).

[93] See Shapiro (1973) for general discussion of Hobbes's optics. That phantasms, or images, are the subject of optics is an essential point of Hobbes's mechanical optics (Shapiro 1973, 148). Both Hobbes's optics and Descartes' optics are mechanical insofar as there are no *species* or spheres of activity. Throughout the changes Hobbes makes to his account of the propagation of light (cf. fn. 26), his optics is consistently a continuum theory and not an emission theory. Shapiro claims that prior to 1636 Hobbes held an emission theory, wherein light corpuscles are transmitted

Hobbes's two goals in *De homine* 2 are interconnected. He first establishes the concept of the visual line and then uses the account of the visual line to explain how humans perceive motion. Hobbes' discussion "concerning the perception of motion" (*de perceptione motus*) is, of course, meant to explain how humans perceive *bodies* in motion. My case study will focus upon the visual line, but before discussing the visual line it is important to discuss the perception of motion since his explanation of the perception of motion depends upon his account of the visual line. I summarize the Latin text from *De homine* 2 in what follows, making reference to the text as necessary.

Since on Hobbes's account all vision which occurs outside of the optic axis is confused and feeble,[94] to have complete vision of a moving object the eye must be moved to follow it or, if the object is close and moving, the head must be moved.[95] Moving the eye or head keeps the moving object in the line of the optic axis, thus allowing for clear vision. Hobbes takes his claim that the visual line is the only line through which clear vision occurs to be novel. In *MDO* he argues that his theory of the optical line contradicts previous theories of vision, which claimed that there were "other visual lines by which we see distinctly besides the optique axis" (Hobbes 1983c, 622; EW VII.470). However, Alhazen's theory of vision also emphasized that the clearest vision occurs at the perpendicular through the optic axis and held that refraction occurs so that rays are bent toward the perpendicular (Lindberg 1976, 73-74).

In the demonstration of the visual line Hobbes borrows two geometrical principles from *De corpore* part III. The demonstration would not work without these borrowed principles. First, he

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from the object of vision to the eye (Shapiro 1973, 164-165); however, this view relies upon attributing "A Short Tract on First Principles" (also called the "Little Treatise" in the literature) to Hobbesian authorship. This has been the subject of some dispute, and *pace* Shapiro Robert Payne and not Hobbes most likely authored the Short Tract (see Raylor 2001).

[94] […] *extra axem opticum omnem visionem esse confusam et debilem* (OL II.14).

[95] […] *itaque ad perfectam rerum motarum visionem, oportet semper converti oculum, aliquando etiam, si objecta prope sint et mota velociter, totum caput* (OL II.14).

cites a geometrical principle about refraction from *De corpore* 24.2: "If a movable [body] should cross or there should be a generation of motion from one medium to another of a different density in a line, which is perpendicular to the separating surface, there will be no refraction" (OL I.306).[96] Using this principle from *De corpore* at *De homine* 2.2, he argues that the ray from visual point F in figure 1 will not be refracted (*irrefractus*) because it strikes the eye perpendicularly at point B, and thus will cross through the center of the eye and strike the retina at point D (OL II.8).

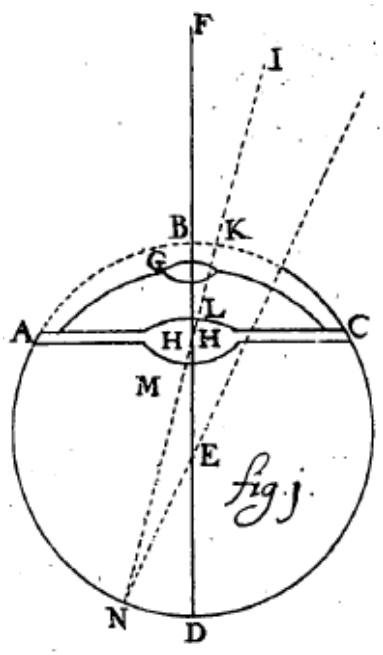

Figure 1. **Diagram from *De homine* 2**

At *De homine* 2.2, Hobbes borrows a second geometrical principle from *De corpore* part III when explaining why a ray from point I which strikes the eye obliquely will, having been refracted, strike the retina at point N, which is to the left of the center of the retina. After the ray

[96] *Si mobile transeat vel motus generatio fiat ab uno medio in aliud densitatis diversae in linea, quae sit ad superficiem separatricem perpendicularis, nulla fiet refractio*.

from I strikes the retina at N, Hobbes argues that it strikes the center of the eye at point E, which causes point I to appear in a different location, N-E, (*punctum visum* I *apparebit alicubi in* N E *producta*) than it would have if the ray from point I had struck the eye perpendicularly through the line of vision. To support the claim that the ray will strike the center of the eye at E, Hobbes borrows a geometrical principle from *De corpore* 22.6 which states that when a body presses against another body without penetrating it that body "must recede through a straight [line] which is perpendicular to that surface at the point it has been pushed back" (OL I.274). This principle explains why the ray from I will appear somewhere in N-E, unlike the ray from F which will appear somewhere in D-F (*apparebitque punctum* F *alicubi in* D F).

Two questions arise from consideration of this case study from *De homine* 2. How are these principles that Hobbes borrows from *De corpore* in this optical explanation *geometrical*? Why does Hobbes think that such borrowing is legitimate? I will address these issues in the remaining sections of this chapter.

4.2.2 Hobbes's Geometry in *De corpore* Part III

Hobbes's geometry is what might be called a physical geometry. As discussed already (chapter 3), for Hobbes the definitions of simple geometrical figures, such as the definition of 'line', must include the mechanical instructions for constructing a line. However, *De corpore* part III (chapters 15-24) goes beyond such simple geometrical figures and treats topics as far-ranging as endeavor, reflection, and refraction. The geometrical principles that Hobbes borrows and employs in the above case study from *De homine* 2 are from *De corpore* part III, so it is

important to determine in what sense they are *geometrical* and how this is connected with the simple geometry of points, lines, surfaces, and solids.

De corpore Part III is concerned with geometrical topics because it treats motion and magnitude, which for Hobbes are "the most common accidents of bodies" (OL I.75). In concluding part III, he advises that the third part is now complete, "in which we have considered motion and magnitude in themselves and in the abstract" (*per se et abstracte*) (OL I.314). The section which follows, part IV, is concerned with what Hobbes describes as the phenomena of nature. To be concerned with the "phenomena of nature" is to deal with the "motion and magnitude of the bodies of the world—the ones which exist in the actual [world]" (*de motu et magnitudine corporum mundanorum sive quae re ipsa existunt*) (OL I.314).

This distinction between bodies in the actual world and the abstract features of bodies in the world, such as motion and magnitude, is essential for understanding Hobbes's philosophy and how he understands mixed mathematics. Like many of his contemporaries, for Hobbes the distinction to be made is between pure and mixed mathematics, not pure and applied mathematics; any discipline in which we discover 'abstract' principles is pure and any discipline in which we borrow these principles for explanations is 'mixed'. Hobbes discusses the distinction further in *De homine* 10.5, and there he also provides an answer to the question of why it is legitimate to borrow from geometry in natural philosophy:

> […] since one cannot proceed in reasoning about natural things that are brought about by motion from the effects to the causes without a knowledge of those things that follow from that kind of *motion*; and since one cannot proceed to the consequences of motions without a knowledge of *quantity*, which is geometry; nothing can be demonstrated by physics without something also being

> demonstrated *a priori*. Therefore physics (I mean true physics) [*vera physica*], that depends on geometry, is usually numbered among the mixed mathematics [*mathematicas mixtas*]. […] Therefore those mathematics are pure which (like geometry and arithmetic) revolve around quantities in the abstract [*in abstracto*] so that work [in them] requires no knowledge of the subject [*cognitione subjecti*]; those mathematics are mixed, in truth, which in their reasoning some quality of the subject [*subjecti aliqua proprietas*] is also considered, as is the case with astronomy, music, physics, and the parts of physics that can vary on account of the variety of species and the parts of the universe (Hobbes 1994a, 42; OL II.93).[97]

The literature has unfortunately paid little attention to this passage from *De homine* 10.5 and considered the implications it has for our understanding of the relationships among the Hobbesian *scientiae*,[98] which is unsurprising given the general lack of interest there has been in

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[97] I have modified Gert's (Hobbes 1994a) translation to reflect the parallel use of *subjectum* as that which distinguishes "pure" from "mixed" mathematics; Gert inserts 'fact' when translating the phrase relating to the former.

[98] Two studies have addressed this issue of "borrowing" without mentioning this passage, but both have shortcomings. Sacksteder (1992) holds that principles are "borrowed" from first philosophy in physics and from geometry in physics but without any explanation for why Hobbes would have thought this "borrowing" was licensed. Instead, he claims that these principles could be "borrowed as seems fit" (Sacksteder 1992, 768). Talaska (1988) argues that Hobbes, contra Suarez in *Disputationes metaphysicae* (1.5.51), views all other sciences as subalternated to "metaphysics", which he claims is "Hobbes's explicit view in the ninth chapter of the Latin *Leviathan* and elsewhere" (1988, 20-21). Given his general distaste for 'metaphysics', Hobbes would likely not have characterized his account in this way, but Talaska's reference to Suarez is interesting, since we know that Hobbes read Suarez. For example, Hobbes quotes a title of a chapter written by Suarez (EW III.70), mentions his name at various other points (EW VI.185; EW IV.330), and criticizes Suarez's account of free will and the divine concurrence of human action (EW V.18, 37; cf. also EW V.176, 266). Although Hobbes never explicitly asserts that all sciences are "subalternated" to "metaphysics" in the Latin edition of *Leviathan*, *pace* Talaska (1988), he does say that "since subjects of the sciences are bodies, it [philosophy] is classified into species in the same way the bodies themselves are classified into species, i.e., so that they more universal precede the less" (Hobbes 1994b, 49).

De homine (cf. fn. 10) and the limited attention that has been paid to Hobbes's optics by those working on Hobbes's philosophy more generally.

The section in *De homine* 10.5 immediately preceding this quotation contains one of Hobbes's clearest statements about maker's knowledge and geometry. Hobbes argues that we possess maker's knowledge in geometry because "we ourselves draw the lines". However, since "the causes of natural things are not in our power" we can demonstrate only what their causes could have been. This form of demonstration found in natural philosophy is *a posteriori*, which for Hobbes means that it is a demonstration from the effects to causes. This brief discussion of geometry and maker's knowledge sets up the claims that Hobbes makes in extended quotation from *De homine* 10.5 provided above. For Hobbes the only way for one to reason from the effects to the causes in natural philosophy is for one to know *already* what the causes are. One must know what things follow from the kind of motion that occurs in a given phenomenon, and one must know the causes of quantity to know this about motion. Thus, Hobbes pronounces that "nothing can be demonstrated by physics without something also being demonstrated *a priori*" (Hobbes 1994a, 42; OL II.93). For Hobbes *a priori* simply means from the causes—we are able demonstrate from the causes when prior to any investigation undertaken in natural philosophy we have our geometrical principles already in place.[99]

On Hobbes's account, then, working in "pure mathematics" allows one to deal with quantities in the abstract (*in abstracto*). In pure mathematics one does not consider the qualities that are unique to that type of body, e.g., whether the body has the capability of sense (as

[99] See footnote 13 in chapter 3 for discussion of two principles which Douglas Jesseph (2013, 58) argues come prior to natural philosophy: what Jesseph calls the "persistence principle" in *De corpore* 8.19 (OL I.102-103) and the principle of action by contact in *De corpore* 9.7 (OL I.110-111). I argue in fn. 13 of chapter 3 that these two principles themselves are dependent upon first philosophy. Rather than being "demonstrable from the very definitions," as Jesseph holds, the persistence principle follows directly from consideration of the simplest conceptions established by the annihilation of the world thought experiment, begun in *De corpore* 7.

discussed *De corpore* 25.5 in part IV). Instead, one considers only the abstract properties of the body. In natural philosophy, however, one must also consider the qualities of the body under consideration that are not treatable generally. In natural philosophy one must also consider the qualities that "vary on account of the variety of species and the parts of the universe" (Hobbes 1994a, 42; OL II.93). So for Hobbes "true physics" (*vera physica*) is that which "depends on geometry" and, since it *also* must consider qualities unique to certain kinds of bodies, it is part of the mixed mathematics disciplines (*mathematicas mixtas*). It is a mixture of physical suppositions (e.g., the nature of light) and geometrical principles (more on this below).

Hobbes makes a similar distinction between pure and mixed mathematics in *Anti-White*,[100] his unpublished extended critique of Thomas White's *De mundo dialogi tres* (1642). Hobbes argues that since no one writing in morals or physics has written anything that is not "open to question" only arithmetic and geometry are mathematical. Without such ignorant writers on morals or physics, he argues, morals and physics too would be *mathematical* (see epigraph above; Hobbes 1976, 24; MS 6566A, f. 5 *verso*). However, Hobbes argues that, in addition to geometry and arithmetic, what are traditionally considered the mixed mathematics disciplines should also "be counted among mathematical [*mathematicarum*]" sciences (MS 6566A, f. 6). Hobbes includes astronomy, mechanics, optics, and music among these and, interestingly, leaves the door open for "others yet untouched [*et alia adhuc intactae*]" (MS 6566A, f. 6).

The distinction Hobbes makes in *Anti-White* between pure mathematics and mixed mathematics is exactly like what we have found in *De homine* 10.5 between considering bodies in the abstract and bodies as they are the actual world. In *Anti-White* the mixed mathematics

[100] See Malcolm (2011) for reasons to doubt that Mersenne's references to *Anti-White* as "*de motu, locu & tempore*" should be understood as referring to the title of the work.

disciplines should be counted as part of mathematics since they consider "quantity and number, not [merely] abstractly [*non abstracte*], but with regard to the motion of the stars, or the motion of heavy [*gravium*] [bodies], or with regard to the action of shining [*lucidorum*] [bodies], and of those which produce sound [...]" (MS 6566A, f. 6).[101] So in addition to considering quantity and number in the abstract, again we find the mixed mathematics disciplines treating bodies on account of their unique qualities, such as shining.

4.2.3 *De homine* Case Study Revisited

Let us now return to the case study from *De homine* 2 and consider how the explanation Hobbes provides can be viewed as a mixed mathematical explanation of the sort described in *De homine* 10.5 and *Anti-White*.[102] The two principles which Hobbes borrows from *De corpore* (from 22.6 and 24.2) both describe the motions of bodies irrespective of the type of body they are—in this sense they are part of pure mathematics. The principle from *De corpore* 22.6 concerns the behavior of a hard body moving in a straight line by means of two uniform motions. Hobbes demonstrates by means of a constructed geometrical diagram that if such a body should "strike or rest on [another] body, without penetrating it, nevertheless it will give to the part on

[101] Jones (Hobbes 1976) misleading translates '*non abstracte*' as 'not merely in theory', missing the connection between the discussion here in *Anti-White* and *De homine* 10.5.

[102] Malet (2001, 315-317) argues that for Hobbes geometry and natural philosophy are "separate deductive systems," citing the table of the sciences in *Lev* IX where optics is under physics. However, music is under physics on this table as well (EW III.72-73), and Hobbes mentions music as well as optics as mixed mathematics disciplines. What is at issue with regard to the table in *Lev* IX, *contra* Malet, is not whether optics is fully part of physics or not, but rather the extent to which it is *mathematical*.

which it strikes or rests an endeavor [*conatus*][103] and must recede through a straight [line] which is perpendicular to that surface at the point it has been pushed back" (OL I.274).[104]

To establish this principle, Hobbes instructs the reader to construct a figure (see figure 2 below). With the figure constructed, Hobbes considers the motion of a hard body traveling along the straight line EA which strikes another hard body ABCD. The proof by construction of a geometrical diagram relies upon distinguishing between the two uniform motions that are moving the body in question along EA, i.e., one motion which is along EF and the other motion which is along ED.

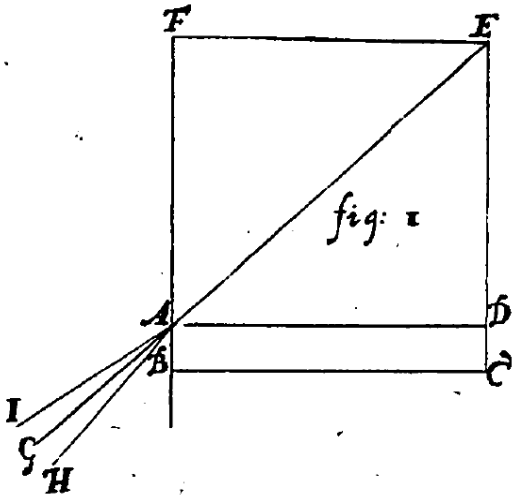

Figure 2. **Diagram from *De corpore* 22.6 (from 1655 edition)**

Since the motion along EF does not contribute anything with respect to the body's impact with ABCD at A, the total endeavor (*totus* [...] *conatus*) that the mobile body has to pass through or press against AD is "from the perpendicular motion or endeavor in FA" (*a motu vel conatu*

[103] For Hobbes endeavor (*connatus*) is motion that is too small to be measured (*De corpore* 15.2, OL I.177).
[104] *Si corpus in corpus impingat vel innitatur, nec ipsum penetret, dabit tamen part, in quam impingit vel innititur, conatum recedendi per rectam, quae sit superficiei ejus in puncto impactus perpendicularis*.

perpendiculari in FA) (OL I.275). As a result, when the mobile body moving along EA strikes ABCD at A only the motion along FA will be affected; the motion along FE will not be affected and so the moving body will be reflected.[105] Even though in Hobbes's optics light is not transmitted by means of a something material leaving a luminous body, such as a *species*, and traveling through a medium to the eye, Hobbes takes this principle of reflection to hold for both body-body collisions and for propagation of motion through a medium (more on light below), as he argues in *De corpore* 24.9 (OL I.314).

The second geometrical principle to which Hobbes appeals in *De homine* 2 is necessary to support his claim that there is no refraction when a ray hits the eye on the optic axis (B in figure 1 above). He establishes in *De corpore* 24.2 that there is no refraction when a body moves between two media in a line perpendicular to the surfaces of both media; nor is there refraction when motion is propagated in a perpendicular line between two media (I will discuss the latter since it is most relevant to the case of vision).

Hobbes demonstrates this non-refraction principle with a *reductio ad absurdum* argument which depends upon the geometrical concept 'perpendicular' (OL I.306-307). The peculiar argument that he offers goes as follows. When motion occurs perpendicularly whatever occurs on one side of the perpendicular will be equal to whatever occurs on the other side. If we assume that refraction occurs when motion is propagated perpendicularly to the surface of a medium (the assumption for *reductio*), then whatever inclination there is on one side of the line of motion there must also be on the other side (given the earlier definition of 'perpendicular'). But anything that could cause refraction on one side of the line would also be present on the other side; so

[105] Hobbes's concern in this demonstration is to explain *why reflection occurs* when any moving hard body strikes another hard body. Several chapters later he is concerned with a different *explanandum*—why the angle of reflection is equal to the angle of incidence (*De corpore* 24.8, OL I.312-314). Hobbes provides a geometrical explanation there as well.

Hobbes says that "refraction from one part would destroy refraction from another part" (OL I.307).[106] From which it follows that the "refracted line would either be everywhere, which is absurd; or nowhere, which was the proposition to be shown" (OL I.307).[107] Thus, he holds that there will be no refraction.

Hobbes draws a corollary as a consequence from this *reductio* argument that shows that there is a geometrical cause for all refraction. It does not matter if a hard body is moving from one medium to another or if motion is being propagated between two media, the obliquity of the angle of incidence alone is the cause of refraction (*causam refractionis*) (OL I.307).[108] Likewise, it does not matter what the medium is, whether air, water, or something else.

These two principles from *De corpore* 22 and 24 describe the behavior of bodies considered geometrically, i.e., with only their motion and magnitude considered, and not with any of their unique qualities considered. For example, the corollary just discussed identifies the geometrical cause of refraction in all media irrespective of the unique physical qualities that various media possess. But optics must also consider the unique qualities that media and other bodies possess, which is why it is a *mixed* mathematics discipline. Although Hobbes changes his views on the kind of motion responsible for the propagation of light,[109] throughout his various optical works he holds that vision occurs when motion from a lucid object like the sun presses against the air, is propagated in that medium, and eventually presses against the parts of the eye,

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[106] [...] *refractio ex una parte refractionem ex altera parte tolleret* [...].
[107] [...] *unde linea refracta vel ubique esset, quod est absurdum; vel nulla, quod est propositum ostendere.*
[108] Although here it is not essential, this distinction between refraction of a pulse and refraction of the path of a body is important elsewhere in Hobbes's optics, for Hobbes holds that the motion of a pulse, like light, must be explained differently from the motion of a body. This important difference between his and Descartes' optics is brought out in their 1641 correspondence. Shapiro (1973, esp. 155f.) discusses this difference in detail.
[109] As early as 1636 in a 16/26 October 1636 letter to William Cavendish he demurs on the kind of motion responsible for light propagation: "...if one should ask me what kind of motion I imagine in the medium [...] that I cannot answer" (Hobbes 1994c vol. I, 38). Hobbes later held various other views, e.g., that the propagation was due to dilation and contraction motions (in *Tractatus Opticus II* and *MDO*) or that it was due to simple circle motion (in *De corpore* 27.2, OL I.364).

the brain, and the heart (see *MDO*, Hobbes 1983c, 94; see also *Tractatus Opticus* I, OL V.217). Thus in optics the properties of those various kinds of bodies that propagate the motion—what Hobbes means by the "qualities that vary on account of the variety of the species and parts of the universe" in *De homine* 10.5—must be considered in addition to their abstract geometrical properties.

Another such example of considering the unique qualities of bodies in mixed mathematics follows Hobbes' discussion of the visual line and the perception of motion in *De homine* 2. In Corollary I of *De homine* 2.4, which follows the case study discussed already, to explain the cause of confused vision in old age (what he refers to as "dim-sightedness" [*lusciosi*]), Hobbes makes reference to the dryness that occurs through the process of aging and contracts the retina. The geometrical properties of the rays entering the eye must be known, of course, for the explanation of dim-sightedness, but so also must the properties of the parts of the eye. To provide such an explanation, the natural philosopher working in optics must know the qualities of the subject, as in the extended quotation from *De homine* 10.5 above, but also the principles from "pure mathematics." The natural philosopher must thus mix from these two disciplines to explain these phenomena in "true physics."

4.2.4 Hobbes's Optics and the Deductivist Account

Let us now return briefly to an issue that I introduced in chapter 1. I have been arguing that the demonstration in the case study from *De homine* 2.2 should be understood as a mixed mathematics explanation, wherein geometrical principles and physical suppositions are mixed to provide a demonstration. However, a dominant interpretation (e.g., Peters 1967; Watkins 1973;

Hampton 1986; Talaska 1988) in the literature—what I have called the deductivist account—would understand this explanation differently. The deductivist account has the virtue of taking Hobbes's claims to the unity of his philosophy seriously, but it does so at the cost of committing him to too strong a view of unity—unity achieved through deduction, and sometimes through full reduction. On this view, Hobbes held that all claims in disciplines like natural philosophy and human psychology could be reduced to claims in geometry and ultimately to first philosophy, i.e., claims that would describe only simple bodies in motion (esp. Hampton 1986).

But now let us put the deductivist view to the test by examining how it would describe what Hobbes does in *De homine* 2 when he borrows these geometrical principles from *De corpore*. (It is worth noting that those who have advanced the deductivist account in the literature have not, to my knowledge, examined Hobbes's optics.) If Hobbes had held the deductivist view, one would expect to discover signs of such a deduction occurring here in the context of optics where reference is made back to geometrical work from *De corpore*. Given Hobbes's description of his optics in *De homine* as a "demonstration" (*demonstratio*) (cf. OL II.*Epistola Dedicatoria*), one would further expect that if such a deduction were on offer that it would be displayed here (i.e., in a demonstration the goal is to *show* the steps one takes from that which is to be proved through the proof).

However, we find that Hobbes offers no such explicit deduction or reduction from geometry or first philosophy at all, neither in chapter 2 nor elsewhere in the optical work of *De homine*. Instead, Hobbes simply borrows geometrical principles from *De corpore* without any attempt to provide any intermediate steps between optics and geometrically-considered bodies in motion that would be required for a deduction. In Hobbes's actual natural-philosophical practice, there is no such deduction.

So far I have shown that Hobbes expected that natural philosophy should depend upon geometry. His optical work is just one example of this relationship; in chapter 5, I will argue that his natural philosophy more generally also exemplifies this sort of dependence upon geometry, as well as upon first philosophy. In chapter 6, I will argue that Hobbes's explanation of the commonwealth is this sort of explanation as well. However, I have not shown *why* Hobbes, or his readership, would have thought such dependence was legitimate. In the next section I will discuss the Aristotelian background of the mixed mathematics tradition and argue that for Hobbes borrowing from geometry (and in some cases first philosophy) was legitimate because one is applying causal knowledge—maker's knowledge—to explain natural phenomena.

4.3 ARISTOTLE AND HOBBES ON MIXED MATHEMATICS

The Aristotelian model provides early discussion of the mixed mathematics disciplines. Aristotle notoriously held that each science has its own principles, and so one could not bring the results of a demonstration from one genus, such as geometry, and use them in a demonstration of another genus, such as natural philosophy. However, Aristotle allowed for exceptions when two disciplines were related to one another in a particular way—by means of a relationship called subalternation. One such relationship he discusses is between optics and geometry. In what follows, I will first discuss Aristotle's account of the mixed mathematics disciplines, focusing on optics. In place of the deductivist framework, I will next argue that the Aristotelian mixed mathematics tradition provides the appropriate background for Hobbes's work in optics and his philosophy more generally.

4.3.1 Aristotle on Mixed Mathematics

Aristotle discusses "crossing over" from one discipline to another Book I of *Posterior Analytics* (*APo*).[110] When discussing this at *APo* I.7, he argues that "it is not possible to prove a fact by passing from genus to another [ἐξ ἄλλου γένους μεταβάντα], e.g., to prove a geometrical proposition by arithmetic" (75a38-39). Aristotle's use of μεταβαινείν here and elsewhere in *APo* does not have the negative connotation that some have claimed (e.g., Garver 1988), especially since Aristotle uses it a few lines later to describe a *successful* demonstration: "Thus the genus must be the same, either absolutely or in some respect, if the genus is to be transferable [μεταβαινείν]" (75b8-10).[111] The two genera being the same "in some respect", then, characterizes mixed mathematics for Aristotle.

Aristotle further claims in *APo* I.7 that one cannot "prove by any other science the theorems of a different one, except such as are so related to one another that the one is under the other [θάτερον ὑπὸ θάτερον]—e.g. optics to geometry and harmonics to arithmetic" (75b14-17). James Lennox argues that Aristotle's focus in *APo* I.2 and I.9 is on the distinction "between achieving *unqualified* [ἁπλῶς] or 'universal' understanding and having merely 'incidental' or 'sophistic' understanding of it" (1986, 39-40). In *APo* I.9, Aristotle explains when we have nonincidental, or universal, understanding:

> We understand a thing nonincidentally when we know it in virtue of that according to which it belongs, from the principles of that thing as that thing. For

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[110] Aristotle also treats the mixed, or subalternate, sciences in *Physics* II.2, calling them "the more natural of the branches of mathematics" (194a8-9), and in *Metaphysics* M.1-3, especially at 1078a14-17. For discussion of Aristotelian mixed sciences, see McKirahan (1978), Lennox (1986), Wallace (1991), Hankinson (2005), and Distelzweig (2013). For discussion of Galileo and the mixed sciences tradition, see Machamer (1978).

[111] The last phrase could be rendered more closely to the Greek text as "if the demonstration is going to cross," as Jonathan Barnes translates it in the *ROT* version.

> example, we understand something's having angles equal to two right angles when we know that to which it belongs in virtue of itself, from that thing's principles. Hence if that too belongs in virtue of itself to what it belongs to, the middle term must be in the same kind. If this isn't the case it will be as the harmonical properties are known through arithmetic. In one sense such properties are demonstrated in the same way, in another sense differently; for that it is the case is the subject of one science (for the subject-kind is different), while the reason why it is so is of a higher science, of which the per se properties are the subject (76a4-13).[112]

Here Aristotle argues that in the case of sciences such as harmonics and optics, the facts, the *hoti*, will come from one science (τὸ μὲν γὰρ ὅτι ἑτέρας ἐπιστήμας) while the reason why, the *dioti*, will come from a science which is "above" that science (τὸ δὲ διότι τῆς ἄνω). Aristotle holds that such a move is licensed since the person working in optics can borrow geometrical principles because he studies the objects of optics *qua* line (ᾗ γραμμαὶ) and not *qua* object of sight (ᾗ ὄψις) (*Metaph* Μ.3 1078a14-16). That is, one treats a natural object as a mathematical object; for Aristotle, one arrives at the latter by means of a process of abstraction.[113]

If one read only the discussions in the *Posterior Analytics*, one would think that Aristotle considered optics as *largely* mathematical. Examining Aristotle's actual practice of optics provides a different story. Certainly in his account of the rainbow, a traditional *explanandum* in optics, Aristotle does appeal to mathematics. Drawing upon Aristotle's account in *Meteorology* III.2-6, Lennox highlights Aristotle's distinction between unqualified (ἁπλῶς) optics and

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[112] This is Lennox's translation (1986, 40).
[113] This issue of abstraction and what the status of the resulting thing is has been discussed in the literature, e.g., Lear 1982 and Lennox 1986.

mathematical optics.[114] The former includes both physical explanations and mathematical explanations, while the latter he argues is "the use of the relevant principles of pure geometry in the explanation of the restricted class of geometrical properties instantiated in the patterns of the optical array" (Lennox 1986, 47). In addition to such geometrical explanations, there will be explanations that are physical, such as the explanation of the type of reflection a rainbow is (Lennox 1987, 45). So in explaining a given optical phenomenon such as the rainbow there may be both physical and geometrical explanations involved. However, when Aristotle deals with topics related to optics elsewhere in the corpus, such as discussion of color and what light is in *De Anima* II.7 (418a26-419b2), he often does not appeal to mathematical principles but to only physical ones (cf. Lindberg 1996, xxxvi).

4.3.2 Hobbes and the Aristotelian Mixed Mathematics Tradition

Hobbes was well aware of the traditional distinction in Aristotle and in many other authors since Aristotle between a demonstration of the 'that' and the demonstration of the 'why',[115] and in his discussions of *scientia* he explicitly appeals to the distinction.[116] It is worth highlighting one of these areas in this context with Aristotle's account now in view, but I will return to this issue in greater detail in chapter 5 when discussing Hobbes's natural philosophy:

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[114] See also *APo* I.13, 78b10-17 for discussion of the distinction between mathematical optics and unqualified optics.
[115] These are also referred to by authors in Latin as *demonstratio quia* and *demonstratio propter quid*, respectively. Some connection has been made in the literature between these in Zabarella and in Hobbes, but there are significant differences between Zabrella's method and Hobbes's (see Dear 1998, 150-153).
[116] Hobbes discusses the distinction between the διότι and the ὅτι in Dialogue I of the *Examinatio et Emendatio* (1660; see OL IV), his dialogue critique of John Wallis' *Operum Mathematicorum ...Mathesis Universalis* (1657), but this is mostly with regard to the mathematical demonstration, i.e., instances in which there will be no disciplinary boundary crossing.

> Therefore the method of philosophizing is the briefest investigation of effects through known causes or of causes through known effects. We are said to know [*scire*] some effect when we know what its causes are, in what subject they are, in what subject they introduce the effect and how they do it. Therefore, this is the knowledge [*scientia*] τοῦ διότι or of causes. All other knowledge [*cognitio*], which is called τοῦ ὅτι, is either sense experience or imagination remaining in sense experience or memory" (De corpore 6.1; Hobbes 1981, 287-289).

Here Hobbes connects *scientia* with causal knowledge, distinguishing it from *cognitio* where we have knowledge of the 'that' (*tou hoti*). As I have argued in chapter 3, causal knowledge is available only when one constructs it as a maker. Although Hobbes places significant emphasis on *scientia* as causal knowledge, this does not mean that the *hoti*, the knowledge 'that', is considered less important for the philosopher. On the contrary, Hobbes admits that knowledge 'that' in the case of both natural history and political history is "[...] very useful (no, indeed necessary) for philosophy [...]" (OL I.9; Hobbes 1981, 189). Similarly, in *De homine* 11.10: "[...] histories are particularly useful, for they supply the experiences/experiments (*experimenta*) on which the sciences of the causes rest" (OL II.100).[117] These facts from natural or political history or from sense experience are the data, as it were, that the natural philosopher must know.

Hobbes's explanation of the general cause of all sensation in *De corpore* 25.1-2 and his explanation of the swelling of parts of the body when they become warm in *De corpore* 27.3, which explanation provides a cause for the heat of the sun, take the structure of a mixed mathematics explanation (I discuss these examples from natural philosophy in chapter 5)

[117] Thanks to Simon Brown for drawing my attention to this reference in *De homine*.

wherein both the demonstrations of the *hoti* and the *dioti* are at work. In such an explanation for Hobbes, one begins with the facts from experience (or natural or political history in the case of the commonwealth; to be discussed in chapter 6) and then borrows the cause from geometry or first philosophy (notably, these explanations in *De corpore* 25 and 27 are instances in which Hobbes explicitly cites earlier chapters of *De corpore*). Hobbes is licensed in doing so because, like for Aristotle, one treats a natural object like a mathematical object. Furthermore, Hobbes, like Aristotle, is licensed in treating a natural object like a mathematical object because those very geometrical principles are derived from natural objects. For Aristotle one arrives at mathematical principles by abstracting away physical features, and for Hobbes one arrives at these mathematical principles by analyzing conceptions received in experience down to the simplest conceptions and then synthetically constructing geometrical figures from them.

Given this connection between Aristotle and Hobbes that I am making, it is important to distinguish between treating something in the abstract—like Hobbes thinks we do with bodies in geometry—and abstraction as that which grounds mathematics, the latter of which is part of Aristotle's philosophy of mathematics. Recall that in *De homine* 10.5 and *De corpore* 24 Hobbes characterizes geometry as treating bodies in the abstract, i.e., without considering the unique qualities that they actually possess in the world. Such mathematics treats bodies in the abstract (*in abstracto*) because it attends only to the motion and magnitude of bodies. However, Hobbes grounds mathematics in the experience of construction, not in *abstraction* as in the Aristotelian account. Furthermore, Hobbes does not hold that abstract (ideal) mathematical objects exist, as in the Platonic account.[118]

[118] For discussion, see Jesseph (1993, 167; 1999b, 75-76).

Even if Hobbes does not ground mathematics in the method of abstraction, he does hold that in geometry one *considers* bodies abstractly. For example, the problem he has in *Six Lessons* with Euclid's definition of 'point' as "a breadthless length" is that "there is no such thing as a broad length" (EW VII.202).[119] Instead, Hobbes argues that a line is "a body whose length is *considered* without its breadth" (EW VII.202; emphasis added). That is, when one talks about lines in geometry one is talking about bodies considered *qua* geometrical objects without breadth, though since they are bodies they actually do have breadth. This way of characterizing what the geometrician has great affinity with Lennox's reading of Aristotelian abstraction in optics. Instead of viewing abstraction as imagining a fictional object, what Lear (1982) calls "useful fictions", when Aristotle talks of 'separating' he is using it as "a way of characterizing one's taking a delimited cognitive stance toward an object rather than fictionally imagining it as actually separate" (Lennox 1986, 37). The same can be said for Hobbes.

[119] Although Hobbes and Wallis share (with Aristotle) the view that mathematical objects are abstract, Hobbes's criticisms of Euclid's account of mathematical definitions apply to Wallis as well (OL IV.41-42). Wallis (1657, 13) describes what he calls the ostensive proof of the *dioti* (*Ostensiva* τοῦ διότι) in *Mathesis Universalis* and argues that this type of proof, which is the "most perfect of all" (*omnium perfectissima*) the three he has been discussing, proceeds directly from a definition, such as the definition of a circle. Wallis defines a circle in this proof (which seeks to demonstrate the equality of two lines by examining a third line and drawing two circles) as "*Figura plana, unica linea curva contenta, quae a medio comprehensi spatii aequaliter unbique distat*". From this definition claims that it "immediately follows" (*immediate sequitur*) that all radii are equal and that the lines in the proof are equal to each other; this demonstration is "from the proximate cause" (*a causa proxima*). Hobbes, through interlocutor B, describes this proof in *Emendatio et Examinatio* (1660) not as following from the definition of circle that Wallis provides (which in Hobbes's view would be lacking since it does not include the cause of construction) but instead as being demonstrated "through the efficient cause, truly through the construction of two circles" (*per causam efficientem, nempe per constructione duorum circulorum*) (OL IV.42).

4.4 CONCLUSION

Hobbes's familiarity with and at times praise of Aristotle (as we also saw in chapter 3 with his connection of causal knowledge to *scientia*) should not be taken to demonstrate that Hobbes saw himself as an *Aristotelian*.[120] Indeed, as we have seen in chapter 3, Hobbes held that Aristotle's *Physics* was limited only to demonstrations of the *hoti*, since it was merely hypothetical in character. Instead, his use of phrases like 'mixed mathematics', knowledge τοῦ διότι, and knowledge τοῦ ὅτι, as well as his employment of mixed mathematics explanations, should be seen as Hobbes adapting the Aristotelian account to his mechanical philosophy. For all his notorious rhetoric against the Schools, Hobbes turns out to have more similarities to Aristotle than one might expect, similarities that impacted how he structured his systematic philosophy and how he viewed the connections between the various sciences in it.

Importantly, the strict Aristotelian model of the mixed mathematics and subalternation according to which the method of abstraction enables the use of geometry in sciences such as optics was not the only one available in Hobbes's time. Numerous others both closely preceding and contemporaneous with Hobbes demonstrated special concern for the mixed mathematics and their relation to other sciences such as geometry. For example, Robert Payne, a known associate of Hobbes through the Welbecke Abbey circle, was familiar with Robert Grosseteste's works;[121]

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[120] Although not willing to identify himself as an Aristotelian, Hobbes's extensive familiarity with Aristotle's Greek lends support to my account that he was influenced by Aristotle's account of mixing sciences. Little is known about what versions of Aristotle's *Organon*, and especially his logical works, Hobbes had at his disposal. Chatsworth ms. E.1.A notes only that the Hardwick library contained "Aristotle, Opera" in both Latin and Greek (cf. Hamilton 1978). The claim that Hobbes had direct engagement with the Greek *Posterior Analytics* is given some support by looking to *Examinatio et Emendatio* (1660), where Hobbes criticizes Wallis (1657). Both Hobbes and Wallis cite, in Greek, Aristotle's definition of ἀποδείξις and the characteristics of the premises of a demonstration from *Posterior Analytics* I.2, 71b17-23 (compare OL IV.35 with Wallis 1657, 8).

[121] Pacchi (1968a; 1968b) assumed that Chatsworth ms. E1, a library catalogue, was in Hobbes's hand; however, Malcolm (2002, 80-145) cogently argues that it is in Robert Payne's hand.

Grosseteste treats mixed mathematics in his commentary on Aristotle's *Posterior Analytics*, using the term 'abstract' to describe the objects of "pure" mathematics (Laird 1983, 50-51), and did work in optics (McEvoy 1982, 206-211; also see Crombie 1953). Keckermann's *Systema compendiosum totius mathematices* (1661) distinguishes between geometry, which treats figures in the absolute, and disciplines like optics which connects geometrical figures with particular properties of bodies, such as colors.[122]

Additionally, Francisco Suarez (1548-1617), Christopher Clavius (1537-1612), Francis Bacon (1561-1626), and Isaac Barrow (1630-1677), individuals with whose work Hobbes would likely have been familiar, treat the issue of the mixed mathematics disciplines and their relationship to geometry, as well as the relationship of metaphysics to the other sciences.[123] William of Ockham, in particular, comments in *Summa Logicae* that just like Aristotle argued in *APo* that certain parts of medicine are subalternated to geometry (e.g., in the case of circular wounds healing more quickly), "[...] it is not absurd that logic and metaphysics should in some parts subalternate to themselves some parts of the particular sciences" (2007, 182). On Ockham's view, then, sciences in which the principles of logic or metaphysics are used could plausibly be understood as subalternated to logic and metaphysics.[124]

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[122] The 1661 edition: "...nam Optica Geometriae, id est, tractat de figuris geometricis non absolute, ut ipsa geometria, sed concrete, quaetenus istae figurae geometricae conjunctae sunt cum radiatura lucis aut coloris, sive cum qualitatibus visibilibus" (1661, 31).

[123] Regarding Hobbes's references to Suarez, see fn. 18. For discussion of Bacon and mixed mathematics, see Garber 2010. Also, others whom Hobbes read, such as Galileo and Descartes, were influenced by the mixed sciences tradition (see Machamer 1978; Biener 2008).

[124] Ockham distinguishes between 'subalternating science' in two senses: a strict sense and a broad sense. It is in the broader sense that he holds that "it is not absurd" to think of sciences being subalternated to logic and metaphysics. He argues that "[s]ubalternating science is taken more strictly when the principle is known through one science and the conclusion through the other and at the same time the subject of one is accidentally under the subject of the other, or some subject of one conveys a part of what is signified through the subject of the other" (2007, 182). This strict sense, Ockham argues, is the only sense in which Grosseteste holds subalternation to hold, and so though he says it is not absurd, he concludes that "[...] perhaps, logic subalternates no other science to itself, not even, perhaps, does metaphysics" (Ibid.).

These contemporaries and precursors of Hobbes and their concerns with mixed mathematics lend plausibility to the claim that Hobbes extended the explanatory model of mixed mathematics outside of traditional disciplines, such as optics and harmonics, to include *all of philosophy*. The mixed mathematics were a fixation for many working in this period, so in some ways it should be unsurprising to find Hobbes as well being fascinated with them and adapting them to his purposes. My goal has been to place Hobbes within this tradition and to show that his discussions of the mixed mathematics and what he does in optics show many affinities with Aristotelian view. Much of the remaining work for this argument will be done in chapters 5 and 6 where I show how this framework impacts his natural philosophy and his political philosophy.

Although he sees his own work as part of this mixed mathematics tradition, Hobbes breaks with it in his account of mathematics by grounding geometry in construction and experience (rather than, e.g., in abstraction), as argued in chapter 3, but importantly, as I have argued in the present chapter, such a break with the mixed mathematics tradition does not imply that he abandoned the mixed mathematics tradition completely (*pace* Jesseph 1999b, 74-76). Hobbes abandons the tradition neither in optics nor more generally as a way of understanding the relationship between geometry and natural philosophy and between natural philosophy and political philosophy.

Furthermore, Douglas Jesseph argues that "Hobbes did not see some kind of conceptual gulf between mathematical and physical objects, or between what we would call pure and applied mathematics" (2004, 207-208). Agreeing with Jesseph on this point, I suggest, however, that the reason why Hobbes does not see such a gulf between physical and mathematical objects is the same for him as it is for Aristotle, namely that the objects of mathematics are themselves are wholly dependent upon bodies in the world. Additionally, also like Aristotle, I have argued

that Hobbes sees the relationship between geometry and natural philosophy as being between pure and mixed sciences. As a result, one is licensed in using the abstract properties one discovers in geometry in explanations of the behavior of bodies in the world, but one does so by mixing abstract with unique properties.

5.0 HOBBES, BOYLE, AND NATURAL PHILOSOPHY AS "TRUE PHYSICS"

> [...] ingenuity is one thing and method [*ars*] is another. Here method is needed. The causes of those things done by motion are to be investigated through a knowledge of motion, the knowledge of which, the noblest part of geometry, is hitherto untouched.
> *Dialogus Physicus* (Hobbes 1985, 347)

5.1 INTRODUCTION

The discussion in Chapter 4 of Hobbes's work in optics leads into my argument in the present chapter that Hobbes understood natural philosophy more generally to be an example of what he called "true physics" in *De homine* 10.5. True physics, in Hobbes's terms, is a mixed-mathematical discipline. In this chapter, I provide further support for my argument that the dependence of Hobbesian natural philosophy upon first philosophy and geometry should be understood in this way. In Hobbes's mixed-mathematical natural philosophy, one may appeal to either everyday experience or to experiments, even experiments with air pumps, for the 'that'—the *hoti*. However, for the 'why'—the *dioti*—one must borrow causal principles from geometry or first philosophy.

Hobbesian natural philosophy, as I show, relies upon suppositions that bodies behave according to these borrowed causal principles from geometry or first philosophy (e.g., Hobbes

supposes that the sun moves the air around it by a simple circular motion),[125] but the causal principles themselves are grounded in maker's knowledge. In other words, we can know that certain types of motion necessarily generate other types of motion because we prove this abstractly in geometrical constructions; what we do not know is whether bodies in the actual world, such as the sun, do *in fact* move in those ways. So Hobbes relied upon the supposition that they act that way, and then the geometrical principles from geometry can be borrowed in natural-philosophical explanations. This dependence of natural philosophy upon maker's knowledge from geometry not only characterizes Hobbes's views of his own natural philosophy, but moreover I show that his criticisms of Robert Boyle relate to this exact point and, *pace* Shapin and Schaffer (1985), neither to the status of either individual's philosophy as *mechanical* nor to the status of experiment as such.

First, I examine two explanations from *De corpore* part IV: 1) the explanation of sensation in *De corpore* 25.1-2; and 2) the explanation of the swelling of parts of the body when they become warm in *De corpore* 27.3. In both explanations, I show how Hobbes uses maker's knowledge from geometry and first philosophy by explicitly borrowing—to use the term I introduced in chapter 4—causal principles from these earlier sections of *De corpore*; to my knowledge these explicit references back to the earlier sections of *De corpore* (and the others which I mention) have been unnoticed by commentators.[126] My examination of these explanations displays how Hobbes's explicit citations in *De corpore* Part IV should be

[125] Mintz (1952) suggests Galileo's *Dialogo* as a source for Hobbes's causal principle of simple circular motion, as does Brandt (1927, 330ff).

[126] Other instances of this borrowing in addition to those discussed in this chapter include the following from *De corpore* Part IV: *De corpore* 25.6 (OL I.321), *De corpore* 25.13 (OL I.333), *De corpore* 26.3 (OL I.339), *De corpore* 26.6 (OL I.349), *De corpore* 26.8 (OL I.353 and OL I.354), *De corpore* 26.10 (OL I.357), and *De corpore* 30.4 (OL I.417).

understood as Hobbes alerting the reader that he is borrowing causal principles for a mixed mathematics explanation.

Next I reexamine Hobbes's debate with Robert Boyle in light of my account of Hobbes's mixed-mathematical natural philosophy. I argue that this dispute between Hobbes and Boyle is about what counts as "true physics," in the sense which I have explicated already. Instead of understanding Hobbesian natural philosophy as "a causal enterprise ... [that] as such, secured total and irrevocable assent" (Shapin & Schaffer 1985, 19), my account shows that, *pace* Shapin and Schaffer, Hobbes's views about the dependence of natural philosophy upon geometry fall within the broader Aristotelian mixed mathematics tradition. My view acknowledges the social and institutional aspects to the Boyle-Hobbes debate, which Shapin and Schaffer have helpfully brought to the forefront of the literature on this debate, but by focusing upon Hobbes's interests in broader natural-philosophical and mathematical issues, as well as Hobbes's own practice of natural-philosophical explanation, I reject their understanding of the philosophical dispute between Hobbes and Boyle. I argue that Hobbes's harsh criticisms of Boyle's program, especially in the *Dialogus Physicus, sive De natura aeris* (1661; hereafter *Dialogus Physicus*) should be understood as Hobbes advancing his own view of the relationship of geometry and natural philosophy in terms of the mixed mathematics tradition.

5.2 *DE CORPORE* PART IV AS MIXED-MATHEMATICAL "TRUE PHYSICS"

5.2.1 The Explanation of Sensation in *De corpore* 25.1-2

Hobbes's well-known account of sensation in *Leviathan* I (EW III.1) depends upon the explanation that he provides in *De corpore* 25, as Hobbes tells the reader of *Leviathan*. Chapter 25 is the first chapter of Part IV of *De corpore*, which part is devoted to "Physics, or Concerning the Phenomena of Nature" (*Physica, sive de Naturae Phaenomenis*), and as a result it includes some discussion about what Hobbes thinks physics is. To explain what physics is, Hobbes first provides a definition of *philosophy* which is slightly different from the other two definitions that he provides earlier in *De corpore*. He holds that philosophy is "knowledge [*cognitionem*] having been acquired through right ratiocination, of effects from known [*cognita*] generation, and of some generation which may be, from known effects or phenomena" (OL I.315).[127] The first path, as it were, of philosophizing according to this definition is from *causes already known*—this is the path that begins from geometry and first philosophy wherein we are makers.

However, *De corpore* Part IV is concerned with the second path of philosophy—the path which begins from "known effects or phenomena." Hobbes clearly expresses that the *actual* causes of the things in nature are simply not available to us: "[...] I do not say *are generated*, but how they *can be generated*" (OL I. 316; emphasis added).[128] These comments on the status of natural philosophy reflect Hobbes's view on the differing levels of certainty that can be achieved in geometry, first philosophy, and natural philosophy. As I have argued in chapter 3, maker's

[127] [...] *effectuum ex cognita generatione, generationis alicujus, quae esse possit, ex cognitis effectibus sive phaenominis, per rectam rationcinationem cognitionem acquisitam*.
[128] [...] *non dico generata sunt, sed generari potuerunt*. Hobbes holds that there are only bodies in motion in the world, but this supposition in first philosophy does not determine what *kinds* of motions, for example, are responsible for phenomena.

knowledge is the paradigm of *scientia* for Hobbes, but Hobbes holds that natural philosophy lies somewhere between the full certainty of geometry and first philosophy and the limited prudence that characterizes those who have no causal knowledge and rely solely on memory and associations. Hobbes does not hold that natural philosophy is constituted by mere "good guesses," *pace* Martinich (2005, 174). Instead, borrowing causal principles (maker's knowledge) from geometry and first philosophy transfers some of the certainty had there to parts of a natural-philosophical explanation. In what remains of this section, I will show how this relationship between maker's knowledge in geometry and first philosophy is worked out in Hobbes's explanation of sensation in *De corpore* 25.1-2.

Explaining sensation is necessary as the first part of natural philosophy because natural philosophy begins with the appearances of nature (cf. the title of Part IV). Before discussing particular appearances Hobbes discusses *appearing itself* (*ipsum* τὸ φαίνεσθαι), which he calls the "most admirable [*admirabilissimum*]" of all appearances (OL I.316). Since appearances are the starting points (*principia*) by which all other things are known, he argues that sense, the faculty by which we are aware of such appearances, is the principle by which all other principles are known, that is, "all knowledge [*scientiam*] may be said to be derived from it [sense]" (OL I.316). More succinctly, we know only through appearances—phantasms—but the only way that we become aware of those phantasms and inspect those phantasms is through the faculty of sense. So phantasms are the beginning of the inquiry into anything and our inquiry into phantasms must begin with the faculty of sense.

The faculty of sense is a stopping point against any potential regress which would require additional faculties to be supposed, e.g., Hobbes's philosophical psychology lacks a faculty of intuition. For Hobbes we are aware of the faculty of sense not by some other faculty, but, he

says, by *sense itself* since anyone who has sensed remembers that he has sensed. So there is no faculty by which we know that we have sensed or by which we judge sensation: "For sensing oneself [as] having sensed is to remember" (OL I.317).

Hobbes's explanation of sensation in *De corpore* 25 takes place in several steps wherein he presents three separate definitions of *sense*. These three definitions are given by a series of successive refinements, with each refinement being due to him borrowing relevant causal principles from first philosophy and geometry. The first definition combines an appeal to experience—Hobbes describes this as something that can be observed (*observare*)—with appeal to a causal principle from first philosophy—and the other two are further refinements developed by appealing to causal principles from first philosophy and geometry.

Hobbes's use of *experience* appeals to a feature of any person's everyday experience, the fact that the appearances of things are continually changing. This appeal to everyday experience constitutes the demonstration of the *hoti* in this explanation:

> But to this inquiry it is proper in the first place to observe [*observare*] that our phantasms are not always the same [*phantasmata nostra non esse semper eadem*], but new ones are constantly being created and old ones are disappearing, just as the organs of sense are turned now to one, now to another object. Therefore, they are produced and pass away, from which it is understood that they are some mutation of the sentient body [*corporis sentientis mutationem aliquam*] (OL I.317).

If we attend to the phantasms that arise in everyday experience (something that we are to "observe"), it is immediately evident that with each new body that we encounter a new phantasm arises and that it quickly disappears once we turn our organs of sense to another body. Since

phantasms are continually produced and pass away, Hobbes infers that they must be some change in our bodies which is "produced" by outward bodies. Notice that, *pace* Tuck (1988a, 37-41), Hobbes is never skeptical that these phantasms are produced by motion from external bodies that continues in our bodies and that our bodies react against that motion (discussed in already chapter 3). Instead, Hobbes's project is to *assume* that such phantasms are caused by external bodies and then to explain both how those phantasms come about as well the character of those phantasms.[129]

From this appeal to everyday experience, Hobbes next considers what can be known from the demonstration of the fact that these phantasms are "some mutation of the perceiving body." Here he explicitly appeals to *De corpore* 9.9,[130] which is in Part II on first philosophy:

> But that all mutation is something having been moved [*motum*] or endeavoured [*conatum*], (which endeavor [*conatus*] is also motion) in the internal parts of the thing changed has been shown (cap. 9., art. 9.) from this: that while the smallest parts of a some body stay the same having been mutually positioned, nothing new happens to those parts, (unless perhaps it may be possible that every part [*totum*] may be moved at the same time), except that it both be and appear to be the same, which at first it was and appeared to be (OL I.317).[131]

From this borrowing of a principle from earlier in *De corpore* as well as the appeal to everyday experience, Hobbes formulates the first definition of sensation: "Therefore, sensation in the sentient can be nothing other than motion of some of the parts inside the sentient [*motum partium*

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[129] Hobbes assumes this as well in *Anti White* (see Hobbes 1976, 79).
[130] Barnouw (1980b, 125-126) suggests that Hobbes's use of the example of sensation in the definition of "all mutation as motion" in *De corpore* 9.9 shows that "Hobbes's 'logic' and 'ontology' involve the sentience of the living creature at a fundamental level" (here 125).
[131] Note that the Molesworth edition and the 1655 edition (cf. Hobbes 1655, 224) incorrectly record this citation as to *De corpore* 8.9. Schumann (Hobbes 1999, 268) corrects the citation to *De corpore* 9.9.

aliquarum intus in sentiente existentium], which moved parts are parts of the organs by which we sense" (OL I.317).

With this first formulation of the definition of sense, Hobbes notes that we have (*habemus*) found the subject of sense (*sensionis subjectum*), which is the organs of sense in which phantasms are created. We have also discovered part of its nature (*partim ... naturam ejus*), which is that it is "some internal motion in the sentient [*motus aliquis internus in sentiente*]" (OL I.317-318). Hobbes's borrowing of the causal principle from *De corpore* 9.9, combined with the appeal to everyday experience, thus supplied both part of sensation's nature and the subject of sense.

Hobbes borrows a second causal principle from *De corpore* 9 in the second version of the definition of sensation that he provides in *De corpore* 25. He adds that since all motion must be local motion passed either directly between two contiguous bodies or through a medium, the motion that causes sensation in the sentient must originate from the internal motions of the parts of the object of sense and be carried to the subject of sense. He makes this causal claim by borrowing from *De corpore* 9.7: "In addition, it has been shown (cap. 9., art 7.) that motion cannot be generated except by [a body] moved and contiguous [*a moto et contiguo*]. From which the immediate cause of sensation [*sensionis immediatam causam*] is understood to be in this, that it both touches and presses the first organ of sense" (OL I.318). He adds that: "[S]ense is some internal motion in the sentient, generated by some motion of the internal parts of the object [*generatus a motu aliquo partium objecti internarum*], and propagated [*propagatus*] through media to the inmost parts of the organ" (OL I.318).

With the second definition Hobbes has nearly arrived at the complete definition of sense: "By which words, I have almost defined what sense may be [*quid sensio sit*]" (OL I.318). What

remains is for him to explain why we perceive the objects of sensation as being outside of us rather than inside of us. Given Hobbes's account of phantasms being caused by *internal* motion in the sentient, there is nothing to his explanation, as of yet at least, to explain why we do not perceive that the objects of sense themselves are *inside of us*. Since Hobbes explains sensation by appeal only to the cause of motion, this problem is present for Hobbes in a way that it is not present for others in the 17th Century. Consider the case of vision, though this problem applies to all of the senses equally for Hobbes. Hobbes's explanation of vision employs neither an image on the back of the retina nor any of the natural triangulation similar to what "surveyors" (*mensorium*) do like we find in Kepler's account in chapter III, Propositio IX of *Ad Vitellionem Paralipomena* (1604, 63). Furthermore, Hobbes's explanation does not assume our ability to know objects' locations occurs "as if by natural geometry," an ability to which Descartes appeals in *Dioptrique* (2001, 104). Instead of using these various explanatory resources, Hobbes endeavors to explain all of the properties of vision by referring to motion alone, including the perception of color, the apparent position and location of objects, and the appearance of objects as external. Motion from the object of sense, which is transmitted by means of a medium, and motion resulting from the reaction of the body of the sentient are the only *explanantia* which are mechanically intelligible for Hobbes.

To be consistent with this explanatory constraint, Hobbes posits that we perceive phantasms as being caused by bodies outside of us because of the outward motion from the *resistance* of our body against the motion coming from the object of sense. Hobbes's treatment of the concept *resistance* in *De corpore* 15.2 supplies this causal principle, and again he provides an explicit citation within this explanation of sensation in *De corpore* chapter 25: "Likewise, it has been shown (cap. 15., art. 2.) that all resistance is the endeavour contrary to [another]

endeavor [*conatui conatum contrarium*], that is, reaction" (OL I.318). In sensation, this reaction occurs because "through the natural internal motion of the organ itself [*per motum ipsius organi internum naturalem*]" (OL I.318) there is a resistance to the motion coming from the object of sensation. Since the endeavour moves outward due to this resistance, the phantasm "always appears as something situated outside of the organ [*semper videtur* (φαίνεται) *tanquam aliquid situm extra organum*]" of sense (OL I.318).

This final causal principle allows Hobbes to formulate the complete definition of sensation which includes all of the elements of the previous two definitions and incorporates the causal principle relating to reaction. Although it is drawn from *De corpore* 15.2, which is within Part III on geometry, this principle is within an article designed to expand upon the principles of the doctrine of motion from first philosophy. These principles are repeated from the earlier discussions in first philosophy in the article immediately preceding it (15.1 is titled *Principiorum doctrinae de motu superius traditorum repititio*). With this final causal principle in place, Hobbes defines sensation as "[...] a phantasm made by means of a reaction from an endeavour to [the] outside, which is generated by an internal endeavour from the object, and there remains for some time" (OL I.319).

Immediately before providing the final definition of sensation Hobbes describes what he has been doing in formulating these definitions. He says that that this final definition of sensation is "from the explication of its causes and its order of generation [*ex causarum ejus explicatione et generationis ordine*]" (OL I.318-319). These causes which have been explicated are the very principles we have been examining—the causes relating to motion and reaction which were demonstrated in first philosophy earlier in *De corpore*.

5.2.2 The Explanation of Swelling of the Parts of the Body when Warm in *De corpore* 27.3

Hobbes provides explanations for light, heat, and color in *De corpore* 27. Before beginning these explanations, Hobbes introduces several suppositions about the bodies under consideration. First, he supposes that no matter how small some bodies may be we will suppose (*supponemus*) only that their size is not smaller (*minorem*) than what the phenomena themselves require (*phaenomena ipsa postulabunt*) (OL I.364). Regarding the motion of the bodies under consideration, he supposes only what is needed for the "explication of [their] natural causes [*causarum naturalium explicatio*]" (OL I.364). Finally, he supposes that "in the parts of pure ether, just as in the first matter" there is no motion except what is transferred "by the bodies floating in it [*ab innatantibus sibi corporibis*]" and that these parts of the ether are not liquid (*non liquidis*) (OL I.364).

Hobbes, "with these having been supposed [*His supposititis*]," is first concerned to explain the cause of the light (*lux*) of the sun. He introduces an additional supposition—that the body of the sun "by its simple circular motion [*motu simplice circulari*]" moves the parts of the ether that are near it (OL I.364). This circular motion is propagated through this medium and eventually reaches the organ of sense and the heart of the perceiving human. Hobbes next refers back to his explanation of sensation in *De corpore* 25, discussed already, and states that it is the endeavour outward that is "called light or the phantasm of a lucid [body] [*vocatur lumen sive phantasma lucidi*]" (OL I.365). It is "because of this phantasm that an object is called lucid [*nam propter hoc phantasmata est, quod objectum vocatur lucidum*]" (OL I.365). These considerations are what provide the *possible* cause of the light of the sun: "Therefore, we have a possible cause of the light of the sun [*Habemus ergo lucis solaris causam possibile...*]" (OL I.365).

This may initially appear to be a strange claim, for at first glance it seems that Hobbes thinks that the endeavour moving outward away from the body of the perceiver is the *cause* of the light (*lux*) of the sun. Hobbes is, of course, using the vocabulary relevant to the traditional distinction between *lux* and *lumen* when he provides this possible cause of the light (*lux*) of the sun.[132] Hobbes is using this traditional distinction to differentiate between the two motions involved in perception of light: the motion from the luminous body and the reaction against that motion by the sentient. The *lux* of the sun is thus the simple circular motion propagated through medium and the *lumen* is created because of the outward reaction of our bodies to the *lux*.

Hobbes's account in *Elements of Law* (Part I called *Humane Nature*) helps clarify this explanation in *De corpore* 27.2. Instead of the simple circular motion that we find in *De corpore*, in *Elements of Law* Hobbes holds that the motion produced by fire and other lucid bodies is "dilation, and contraction of it self alternately, commonly called scintillation or glowing" (Hobbes 1650, 13). Apart from this difference in the type of motion between *Elements of Law* and *De corpore*, though, his account of the perception of light is largely the same:[133]

> Now the interiour coat of the Eye is nothing else but a piece of the *Optick* nerve; and therefore the motion [from the lucid body] is still continued thereby into the *Brain*, and by *resistance* or reaction of the Brain, is also a *rebound* into the Optick nerve again; which we *not conceiving* as motion or rebound from within, do think it *without*, and call it *light* [...] (Hobbes 1650, 14).

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[132] Lindberg (1978, 356) notes that the *lux*/*lumen* distinction became entrenched through the Latin translation of Avicenna's *De Anima*. For Avicenna the *lux* referred to the light from luminous bodies, such as the sun, and *lumen* referred to the effect of *lux* upon the medium and the non-luminous bodies which it lit (For discussion of Grosseteste's use in *De Luce*, see Grosseteste 1942, 5-6). Hobbes employs these terms with this usage, but others, such as Roger Bacon, use the terms but without there being a consistent distinction made between them (cf. Lindberg 1983, 365 n. 10).

[133] The Latin terms *lux* and *lumen* are not present, since *Humane Nature* was written in English.

So *lux* from the sun or any other lucid body is nothing other than the simple motion coming from the lucid body (or *scintillation* in *Elements of Law*). This motion propagates through a medium, continues to the eye, and then rebounds outward after meeting resistance, creating *lumen*. This outward motion, which he notes in *Elements of Law* is not conceived of *qua* motion, is what causes us to have the phantasm that we do. This simple circular motion of *De corpore* 27.2, then, is the possible cause of *lux*.

Following this explanation of the possible cause of the *lux* of the sun, Hobbes moves on in *De corpore* 27.3 to explain the heat which accompanies the "generation of the light of the sun [*Lucis solaris generationem*]" (OL I.365). This explanation occurs in three steps, and in two of these steps Hobbes appeals to experience. The first appeal is used to differentiate the explanandum which Hobbes is investigating from another, and the second appeal is the *hoti* for this explanation. Finally, he explicitly borrows a causal principle from *De corpore* 21.5 relating to *fermentation*. I will focus upon the steps of this explanation in what remains of this section, and I will argue that this borrowing of a causal principle from *De corpore* Part III and the second appeal to experience—the *hoti*—should be best understood as a mixed mathematics explanation.

Hobbes's first appeal to experience shows what we can and cannot infer about lucid bodies from the heat that they cause in us. He notes that we know by experience what it is to perceive heat in ourselves when we grow warm, but we know what it is "in other things [only] by ratiocination [*in aliis autem rebus per ratiocinationem*]" (OL I.365). He continues by distinguishing between (1) the sensation of heat and (2) what we can know about the things that produce heat: "Therefore we recognize fire or the sun making warm, but we do not recognize that it may be hot [*Itaque ignem vel solem calefacere deprehendimus; quod caleat non deprehendimus*]" (OL I.365). Even though in the case of heat that is caused by other creatures

like ourselves we know that those creatures are themselves hot, such as heat caused by a dog laying on one's lap, Hobbes argues that we cannot make the same inference from the heat caused in us by the sun to the properties of the sun itself. This inference that Hobbes is opposing would claim something like the following: anytime a creature causes heat in another creature or body, that creature itself is warm; thus, when a body like the sun causes warmth in us it must also be warm. This inference, Hobbes maintains, is "not necessary [*non necessario*]," for we can no more assert it than we can say that "fire causes pain, therefore it [fire] is in pain [*ignis dolere facit, ergo dolet*]" (OL I.365).

Hobbes say this much about what we *cannot* infer about lucid bodies from the fact that they cause us to become warm. Now he makes a second appeal to the experience of being warm; this time the appeal to experience plays the role of demonstrating the *hoti*.

> But when we are growing hot [*calescentes*], we learn [*comperimus*] that the spirits, blood, and whatever is fluid in our bodies is called forth [*evocari*] from the interior parts to exterior as the degree of heat is more or less, and the skin swells up [*intumescere*] (OL I.365).

Here Hobbes is focusing upon a feature of the experience of being warm that anyone who has had such an experience will recognize, namely, that the pores sweat and the skin swells when one becomes warm.

Hobbes's second appeal to experience in *De corpore* 27.3 demonstrates *that* (the *hoti*) sweating and swelling occurs when a body is heated. Next he provides the reason why (the *dioti*) not only for the skin's behavior when it becomes warm but also the possible "cause of the heat of the sun [*caloris solaris causam*]" (OL I.365). Hobbes's targeted explanandum, then, is the cause of the heat of the sun, but given his reservations on the inference that can be made, mentioned

already, from our experience of heat to the heat of lucid bodies, by 'heat of the sun' here he means that he is seeking the cause of the *sensation of heat* from the light of the sun.

To provide the cause of the sensation of the heat of the sun, Hobbes borrows a causal principle from *De corpore* 21.5, where he introduces the concept of fermentation. Before discussing this instance of borrowing, it is first necessary to address some textual details. When initially referring to *De corpore* 21.5, Hobbes claims that in chapter 21 he had explained how the air (*aerem*) is moved by the simple circular motion of the sun (*a motu solis circulari simplice*). However, as Schumann notes, this likely refers to an earlier version of *De corpore* since there is no discussion of the simple circular motion of the sun in *De corpore* 21.5,[134] or equally as likely this is simply a mistake on Hobbes's part. Even though this claim about the sun moving the air by simple circular motion is absent from all extant versions of *De corpore* 21.5, for my purposes it is sufficient that Hobbes *does* introduce the concept of fermentation in that article, and it is fermentation that provides the causal principle that figures in his explanation of the possible cause of the heat of the sun in *De corpore* 27.3. More generally, Hobbes's supposition that the sun moves the air around it by simple circular motion occurs frequently throughout *De corpore* when explaining various phenomena, even if not in extant versions of *De corpore* 21.5.[135]

Returning from these textual minutiae to the explanation in *De corpore* 27.3, we see that Hobbes first supposes that the sun's simple circular motion moves the air around it so that the parts of the air "perpetually change their places with one another [*loca sua inter se perpetuo commutent*]" (OL I.366). This motion is propagated from the sun to the air that surrounds humans on earth. Hobbes identifies this perpetual change of place with the process of

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[134] Schumann (1999, 304 fn. 2) notes: "*Cette remarque semble faire référence à une version antérieure de XXI.5*."
[135] For example, *De corpore* 26.7 (OL I.351), *De corpore* 26.10 (OL I.358), *De corpore* 27.2 (OL I.364), *De corpore* 27.4 (OL I.367-368), and *De corpore* 28.2 (OL I.381).

fermentation, and he draws attention to an earlier demonstration in *De corpore* where he explains how water is drawn up into the clouds by this same process.[136] Similar to the way in which water is drawn from the ocean and forms clouds, Hobbes explains how "from our bodies the fluid parts from the insides to the outsides may be drawn out by the same fermentation [*ab eadem fermentatione*]" (OL I.366).

Hobbes is drawing on common knowledge that fermentation causes heat, but he is describing this common notion in terms of a particular kind of motion—on his mechanical account fermentation is the perpetual change of place by the parts of air that results in the joining together of homogeneous parts and also produces heat (*De corpore* 21.5, OL I.263-265; more below). His interest in this type of motion is to show how (in the case of clouds) fermentation in the air can draw up water into the clouds and connect this with human sweating. This is a peculiar usage of *fermentation*, but Hobbes is taking the abstract idea of fermentation as this type of motion and then making use of it in physical explanations in phenomena as diverse as sweating in human bodies and cloud formation over the ocean. The account of fermentation in *De corpore* 21.5 is *geometrical* not merely because it is in part III (the section on geometry), but

[136] There is a discrepancy between extant versions of *De corpore* related to this reference to cloud formation and fermentation. Both Latin editions of *De corpore* (1655; 1668) and also the Molesworth *English Works* and English edition of 1656 have this as a reference to a demonstration supposedly contained in *De corpore* 26.8, but such a demonstration is not present in 26.8. However, this reference is missing from the Molesworth *Latin Works* edition, and Schumann follows the OL in his critical edition, claiming that this demonstration Hobbes cites might be in an earlier version of *De corpore* 21.11 (cf. Hobbes 1999, 305). Schumann may have found evidence for this claim regarding *De corpore* 21.11 (though he does not state this) because of a later reference in *De corpore* 28.14 to the formation of clouds. There the 1655 edition (cf. Hobbes 1655, 276) and, following the 1655 edition, the Molesworth *Latin Works* edition (OL I.391) cite an explanation of the formation of clouds that is supposed to be in *De corpore* 21; Schumann follows the OL version and explains the fact that such an explanation is missing in *De corpore* 21 by supposing that it might have been present in an earlier version of chapter 21 (cf. Hobbes 1999, 323). On this citation to chapter 21, the *English Works* edition (EW I.480) follows the English edition of 1656 (Hobbes 1656, 357) and has this citation as being to *De corpore* 26 instead. In positing an earlier version of *De corpore* 21 as the likely location of this explanation, Schumann neglects the possibility that this explanation of the formation of clouds due to fermentation was moved to *De corpore* 28.2, where Hobbes does in fact discuss the formation of clouds (cf. EW I.468-469; OL I.381). It is plausible that Hobbes had once included this explanation in *De corpore* 21, which is in Part III on geometry, as an example of fermentation and circular motion but then later moved it to section IV in his discussions of wind.

more importantly because it describes a type of motion irrespective of the unique qualities of the bodies that move in that way, such as the unique qualities of human bodies or rain clouds.

When the liquid medium (air) is contiguous to the body of some animal and the parts of that medium are fermenting (perpetually changing places with one another), then Hobbes argues that "it is necessary that the parts of the animal contiguous to the medium may endeavour to enter [*conentur ingredi*] into the spaces [*intervalla*] of the divided parts" (OL I.366). Therefore, what part is "most fluid and separable [*maxime fluidum et separabile*]" in the parts of animals goes out first, and its place is filled by other parts which are able to transpire through the pores of the skin (OL I.366).

What happens to the parts of animal bodies that are not able to be separated in this way, to the parts of the body that are not fluid? Hobbes argues that although they are not separated (*non divelluntur*), it is "necessary that thus the whole mass be moved" into the place left by those fluid parts that are being drawn outside of the body (OL I.366). This is necessary "so that all places may be filled [*ut loca omnia compleantur*]" (OL I.366). When all the parts of the body endeavour in this way, Hobbes argues that the body swells: "Therefore, the mass of the body, all striving at the same time in that way, swells [*moles ergo corporis, total simul ea via conans, intumescit*]" (OL I.366). With this appeal to the causal principle of *fermentation*, Hobbes argues that "a possible [*possibilis*] cause of the heat from the sun has been given" (OL I.366). So on this explanation, when we become warm and begin to sweat it is not because the air around us is hot. Rather, we become warm and our bodies swell and sweat because the parts of the air around us are continually changing places and cause the liquid part of our bodies to leave and the other parts of our bodies to swell.

This may seem like a very strange explanation; for it might appear that these fluids simply exit the body because qua fluids they do so more easily than other parts of the body. Indeed, Hobbes calls them the "most fluid and separable" parts. However, the reason why these fluids exit the body is found in Hobbes's account of *fermentation* in *De corpore* 21.5 (OL I.263-265), and this is the causal principle he is borrowing from the geometrical section of *De corpore* (part III). Given his account of fermentation there, these fluids exit the body because they are being separated from the non-fluidic parts of the body and, through fermentation, are being joined with other fluids. That is, in fermentation homogeneous (fluid) bodies are being united through the seething or boiling of fermentation. This movement of the fluid parts of the body outward to be joined with other fluid parts requires the other, non-fluid parts of the body to fill the places left by the extracted fluid parts, and thus causes bodily swelling. Hobbes identifies this process of fermentation with the Lain *fervere*, which means boiling or seething. This process of fermentation, whether in the case of human sweat, cloud formation, or, as Hobbes mentions, young wine (*mustum*), need not be caused by fire (OL I.264). Nevertheless, heat is produced because of the motion in fermentation.

It is important to keep in mind the scope of Hobbes's explicit use of possible (*possibile*) when talking about the cause that he provides for the heat of the sun that we feel. The use of *possible* refers to Hobbes's confidence that the simple circular motion by which the sun moves the ether around it is the *actual cause* of the heat of the sun. In the explanation discussed above, where Hobbes borrows a causal principle (fermentation) from *De corpore* 21, the fact that fermentation is the cause of the effects under consideration, such as swelling of the parts of the body, is not a supposition by itself. That is, the cause that Hobbes provides for the heat of the sun is *possible* not due to his account of fermentation; instead, the supposition that the sun moves the

ether around it by simple circular motion is what makes this a *possible cause*.[137] This possible cause of simple circular motion must be supposed in order for the explanation to work, but if there were some other sort of motion by which the sun moved the air around it, then presumably that motion would, even still, cause the body to swell by means of the same process—fermentation.

That Hobbes viewed the claim that the sun moved the air around it as a *supposition* should be unsurprising given his various explanations of the propagation of light from lucid bodies in media (see my discussion in chapter 4, fn. 29). Since we cannot know if such is actually the case with regard to the sun's motion, we can hold only that if the sun moves the ether in this way then certain effects necessarily follow. Nevertheless, Hobbes's appeal to fermentation, insofar as it is a principle borrowed from his geometry, transfers a degree of certainty to the inference that follows from the supposition that the sun's produces a simple circular motion. As argued already, Hobbes would not have considered the account of fermentation from *De corpore* 21.5 to be *geometrical* merely because he had provided it in part III (the section of *De corpore* on geometry) and then borrowed it for use in natural philosophy. Instead, for Hobbes this is a geometrical principle because it describes a type of motion irrespective of the unique qualities of the bodies that move in that way, such as the unique qualities of *human bodies* or *rain clouds*. To be a geometrical principle for Hobbes, then, is to be a principle that describes the motions of bodies with their unique qualities having been abstracted away, as we have seen in the discussion in chapter 4 of *De homine* 10.5. Furthermore, to be a geometrical principle one must able to construct that principle, such as fermentation, by

[137] Hobbes explicitly identifies his positing of the simple motion of the sun as a supposition (*suppositionem*) in *De corpore* 26.6-7 and sees his discussion there as "confirming the probability [*probabilitatem confirmandam*]" of this supposition (OL I.351). Horstmann (2001, 494-495) connects this supposition with Hobbes's appeal to dilation and contraction in *Tractatus Opticus II*.

beginning with basic geometrical shapes (such as lines and solids) and simple types of motion (such as simple circular motion).

5.2.3 *De corpore* Part IV Reconsidered

These two studies from *De corpore* Part IV display Hobbes's use of both experience and maker's knowledge from geometry and first philosophy in his natural-philosophical explanations. The borrowing from first philosophy and geometry that Hobbes does in these explanations would be difficult to explain on the deductivist account, for in both explanations we find neither an actual deduction nor the suggestion that one could be provided from first philosophy or geometry to these particular explanations in natural philosophy. Instead the borrowing that we find in these explanations, and elsewhere in other explanations in *De corpore* Part IV (see fn. 2), fits the model of mixed mathematics explanations that Hobbes saw as part of "true physics."

We find additional support for this view that "true physics" is mixed-mathematical natural philosophy in Hobbes's comments about failed or limited explanations. In some explanations in Part IV Hobbes thinks that the facts related to the earth's path—the *hoti*—are not sufficiently known so it is useless to search for the causes. For example, though Kepler posits a cause for the eccentricity of the earth's orbit Hobbes holds that the *hoti* is not sufficiently well known and thus those who search for causes do so in vain: "But since the *hoti* is not yet evident, it is in vain for the *dioti* to be searched for [*Quoniam autem nondum constat* τὸ ὅτι, *frustra*

quaeritur τὸ διότι ...]" (Hobbes 1655, 254).[138] Such a demonstration of the *hoti* for Hobbes, as for Aristotle, must precede any search for causes, and without it the search for causes should not proceed.

5.3 MIXED MATHEMATICS AND *LEVIATHAN AND THE AIRPUMP*

Understanding Hobbesian natural philosophy as this sort of "true physics" sheds new light on Hobbes's disagreement with Robert Boyle regarding the air-pump experiments, which is the subject of Stevin Shapin and Simon Schaffer's *Leviathan and the Airpump* (1985). Shapin and Schaffer have cogently argued that the dispute between Hobbes and Boyle was focused upon the status of experimentation. Hobbes did not *completely* eschew experimentation, as Shapin and Schaffer rightly note (1985, 129).[139] However, rather than seeing the issue as primarily about the status of experiment in natural philosophy, as Shapin and Schaffer have it, on my account the issue is *what relationship experience and experiment should have to the causal principles that we must borrow from geometry or first philosophy*.

However, while Shapin and Schafer have helpfully and convincingly brought the social and institutional aspects of Boyle's experimental program to the fore, they have portrayed Hobbes's natural philosophy in a way that is at odds with the account for which I have been

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[138] Hobbes asserts this in the first edition of *De corpore* (1655), and it is transmitted to the English edition of *Concerning Body* (1656, 329) and to the *English Works* edition (EW I.443). However, the *Latin Works* edition (OL I.361) does not contain this, appearing to follow the 2nd Latin edition of *De corpore* (1668); Schumann follows the 2nd Latin edition and OL (cf. Hobbes 1999, 301).

[139] Hobbes, in fact, took seriously the task of explaining experimental results such as the artificial fountain and the Torricellian phenomenon, among others (see Schaffer 1988, 282-283).

arguing in chapter 4 and in the present chapter. In what remains of this chapter, I will raise difficulties for their view and argue that seeing Hobbesian natural philosophy as a mixed mathematics discipline helps make sense of Hobbes's claims not only in Part IV of *De corpore* but also what he says in his criticisms of Boyle's experiments in *Dialogus Physicus*.

Shapin and Schafer (1985) argue for what I have called in chapter 1 the *deductivist* and *conventionalist* interpretations of Hobbes's natural philosophy. Shapin and Schaffer hold that Hobbes was not only a deductivist, describing Boyle's various defenses from Hobbes' criticisms as "protecting the proper procedures of experimental philosophy against the beast of deductivism" (1985, 176), but moreover they argue that Hobbes saw *certainty* as the goal of true philosophy. Such certainty, they contend, was achievable in Hobbes's view only when we begin from *conventions*. On their view, only political philosophy and geometry possess the sort of certainty required of philosophy because both begin with conventions. This certainty from conventions was then transferred to natural philosophy by means of a deduction. My focus in the present section will be upon Shapin and Schaffer's deductivist interpretation of Hobbes's natural philosophy to see the extent to which these case studies presented already and Hobbes's *Dialogus Physicus* fit with their account.[140]

According to their deductivist account, Shapin and Schaffer portray Hobbes as viewing philosophy as "a causal enterprise ... [that] as such, secured total and irrevocable assent" (Shapin & Schaffer 1985, 19). Given this characterization of Hobbes's views, they hold Hobbes did not see what Boyle was doing as *philosophy*. By philosophy, Shapin and Schaffer have in mind Hobbes's various definitions of philosophy in *De corpore* where Hobbes identifies philosophy with analysis and synthesis, whether from known causes to effects or from known effects to

[140] I have provided arguments against the conventionalist interpretation in Adams (forthcoming).

causes (cf. Shapin & Schaffer 1985, 129). However, given Hobbes's continual references in *De corpore* Part IV to the causes therein being *possible*, it is difficult to agree with Shapin and Schaffer that Hobbes saw "total and irrevocable assent" as the goal of all philosophy, at least certainly not for natural philosophy, which was the focus of his debate with Boyle. Furthermore, Hobbes certainly thought that natural philosophy, which he sometimes called physics (cf. EW III.72), was part of philosophy, insofar as in natural philosophy one moves from known effects to causes (which is one part of the definition of *philosophy* that Shapin and Schaffer claim relates to certainty) and, as I have argued in chapter 4 and the present chapter, insofar as one borrows causal principles for use natural-philosophical explanations.

However, even if not for the reasons that Shapin and Schaffer suggest, it is certainly the case that Hobbes refrained from calling Boyle's "experimental program" *philosophy*, given his harsh remarks in *Considerations upon the Reputation, Loyalty, Manners, and Religion of Thomas Hobbes*:

> They can get engines made, and apply them to the stars; recipients made, and try conclusions; but they are never the more philosophers for all this […] not everyone that brings from beyond seas a new gin, or other jaunty device, is therefore a *philosopher*. For if you reckon that way, not only apothecaries and gardeners, but many other sorts of workmen, will put in for, and get the prize. Then, *when I see the gentlemen of Gresham College apply themselves to the doctrine of motion*, (as Mr. Hobbes has done, and will be ready to help them in it, if they please, so long as they use him civilly,) *I will look to know some causes of natural events from them*, and their register, and not before: for nature does nothing but by motion" (EW IV.436-437; emphasis added).

Shapin and Schaffer (1985, 128) note this slander of the fellows of Gresham college, but in quoting this passage they do not include Hobbes's reference to the "doctrine of motion." In light of this reference to motion, as well as the one I discuss below, I wish to recast the debate between Hobbes and Boyle as a debate about the proper dependence of natural philosophy upon geometry and not about whether natural philosophy should supply "total and irrevocable assent," as Shapin and Schaffer have claimed.

Hobbes makes a similar remark regarding motion in the *Dialogus Physicus* when contrasting the *ingenuity* of experiments like Boyle's with Hobbes's own methodological preoccupations (part of which was the epigraph of this chapter):

> If ingenuity were sufficient for the sciences, for a long time now no science would have been lacking to us. For this new Academy abounds with most excellent ingenious men. But ingenuity is one thing and method [*ars*] is another. *Here method is needed. The causes of those things done by motion are to be investigated through a knowledge of motion, the knowledge of which, the noblest part of geometry, is hitherto untouched*; unless I have led the way a little along the path of those who try not for victory but for truth (Hobbes 1985, 347; emphasis added).

By Hobbes's lights, Boyle's explanations fail because Boyle has not made use of geometrical causal principles in his explanations of the phenomena related to the air pump. In other words, Boyle does not have Hobbes's geometrical principles already in place *before* engaging in experiments. Similarly, Hobbes argues in *De homine* 10.5 that "[...] nothing can be demonstrated by physics without something also being demonstrated *a priori*" (OL II.93).

As I have argued in chapter 4, for Hobbes this "something [...] demonstrated *a priori*" is his "physical" geometry:

> [...] since one cannot proceed in reasoning about natural things that are brought about by motion from the effects to the causes without a knowledge of those things that follow from that kind of *motion*; and since one cannot proceed to the consequences of motions without a knowledge of *quantity*, which is geometry; nothing can be demonstrated by physics without something also being demonstrated *a priori*. Therefore physics (I mean true physics [*vera physica*]), that depends on geometry, is usually numbered among the mixed mathematics [*mathematicas mixtas*] (OL II.93).

So Hobbes's criticisms of Boyle's program for failing to "apply themselves to the doctrine of motion" and for lacking *method* (*ars*) rather than mere ingenuity should be understood as Hobbes claiming that Boyle is not doing true physics (*vera physica*). Thus, he is not merely claiming that Boyle's experiments themselves fail to be philosophy; instead, he is claiming that Boyle has misunderstood that the only way that causal knowledge is available in natural philosophy is through its dependence on geometry.

Given my re-interpretation of the Hobbes-Boyle debate in light of what counts as "true physics," it is unsurprising to find Hobbes using his geometry from *De corpore* at key points in the *Dialogus Physicus*.[141] For example, Hobbes appeals to his account of simple circular motion in *De corpore* 21.1 when discussing the spring of air. In the *Dialogus Physicus*, Individual B asserts that "without which hypothesis [from *De corpore* 21], however much work, method or

[141] In addition to the instance in *Dialogus Physicus* to be discussed, Hobbes cites the discussion of endeavor and circular motion in *De corpore* 15 (OL IV.262) and the explanation of the cause of fire in *De corpore* 27 (OL IV.266).

cost be expended on finding the invisible causes of natural things, it would be in vain" (Hobbes 1985, 358; cf. OL IV.249). Later in *Dialogus Physicus*, Hobbes appeals again to *De corpore* 21.1 and 21.10 (cf. OL IV.251).[142] These citations to his earlier work on simple circular motion are not attempts by Hobbes to show that one could *deduce consequences* about air from these principles. Instead, Hobbes is here borrowing causal principles that have epistemic certainty because of their status as maker's knowledge. This borrowing is legitimate not because of some deduction, as Shapin and Schaffer claim, but rather because natural philosophy is a mixed-mathematical discipline in which the causes are borrowed from geometry and first philosophy.

The status of this simple circular motion, discussed already in the context of the explanation of the heat of the sun, is a key point of dispute between Hobbes and Boyle that Schapin and Schaffer address (1985, 204-205). Shapin and Schaffer highlight that, in *An Examen of the greatest part of Mr. Hobbes's* Dialogus Physicus de Natura Aëris, Boyle accuses Hobbes of claiming that bodies are self-moved: "[...] Mr *Hobbes* himself, whatever he says in this place, does elsewhere describe a motion of their own to multitudes of terrestrial corpuscles" (1772, 195). Although Hobbes certainly does not hold that there are corpuscles, since for him *body* is the most basic ontological category, one can see why Boyle accused Hobbes of this. Were Boyle's accusation correct, the consequences would be disastrous for Hobbes's system since a fundamental point in Hobbes's philosophy is that all motion of a body is local motion caused by another body (e.g., see *De corpore* 9.7, OL I.110).

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[142] There appears to be an error in the printing and translation of *Dialogus Physicus* regarding this reference to *De corpore* 21. Molesworth and Shapin & Schaffer (Hobbes 1985, 360) faithfully reproduce these references as being to *De corpore* 2.1 and 2.10 from the original printing (cf. *Dialogus Physicus* 1661 edition, p. 9), but this cannot be the passage to which Hobbes intended to refer since he does not discuss motion at all in *De corpore* 2.1 and 2.10. Instead, in those articles of chapter 2 he discusses names. It is likely that that the 1661 edition of *Dialogus Physicus* introduced this error in printing since there is an odd space between the '2' and decimal point not present in the other references to *De corpore* that are within the text (*Dialogus Physicus* 1661 edition, p. 9).

Furthermore, Boyle drew attention to simple circular motion because of the apparent theological implications of such a view. Shapin and Schaffer argue that Boyle sought to trap Hobbes in a sort of dilemma when he posited simple circular motion: either Hobbes must admit that the first cause (God) is immaterial or that the first cause is a body (Shapin and Schaffer 1985, 204). If Hobbes supposed that the first cause is immaterial, then he would have to admit that something immaterial causes motion in a body. If Hobbes supposed that the first cause is a body, then it would seem that there is "inherent motion to this form of matter" (Shapin and Schaffer 1985, 204). Hobbes would find neither consequence palatable.

Two points are immediately relevant regarding this issue of Boyle's attack on the status of Hobbesian simple circular motion. The first point relates to Hobbes's general lack of concern about God's properties. Although Hobbes does at times entertain the claim that God is a body, such as when he cites the Church Father Tertullian in support of such a view in the Appendix to the 1668 edition of *Leviathan* (cf. Hobbes 1994b, 540), Hobbes is largely unconcerned with God's properties other than the fact that God plays the role of first cause. He argues as early as 1640 in part I of the *Elements of Law*, *Humane Nature*, that "[...] we can no conception or image of the Deity, and consequently, all his attributes signify our inability and defect of power to conceive any thing concerning his Nature, and not any conception of the same, excepting only this, that *there is a God*" (Hobbes 1650, 132). Such themes about the incomprehensibility of God continue in the 1651 edition of *Leviathan* (e.g., EW III, 96-97). Given that these are well-represented views of Hobbes's, it seems that Hobbes would be unconcerned by Boyle's attempt to force him into this dilemma concerning God's properties—it is enough to know *that* there is a first cause even if one cannot know anything more about that cause.

The second point relates to Hobbes's use of the principle of simple circular motion and Shapin and Schaffer's understanding of this aspect of the Hobbes-Boyle debate. Shapin and Schaffer argue that the back and forth between Hobbes and Boyle about the status of simple circular motion concerned primarily whether or not each party was a true advocate of *mechanical* philosophy. They note that "[...] each was in a position plausibly to charge the other with serious violations of mechanism" (Shapin and Schaffer 1985, 205). While Boyle was undeniably interested in the status of his work as *mechanical philosophy*, Hobbes was not similarly concerned with his natural philosophy as being part of what Boyle identified as *mechanical philosophy*. Instead, Hobbes's preoccupation in his statements in *De corpore* and *De homine*, as well as the parts of *Dialogus Physicus* already discussed, was with proper method, where *method* relates to how geometry and first philosophy are related to natural philosophy. Hobbes's natural philosophy is rightly described as mechanical, but the focus of his criticisms of Boyle's experimental program is not about Boyle's work as *mechanical* philosophy; rather, they are about it as *philosophy* generally speaking. In Hobbes's lights, Boyle's philosophy simply fails to get at causal knowledge, insofar as it lacks the foundational work in geometry and first philosophy that Hobbes saw as essential to all natural philosophy.

5.4 CONCLUSION

I have argued that Hobbes's references to first philosophy and geometry within the explanations in *De corpore* Part IV are best understood as the borrowing of causal principles. This borrowing, I contend, is legitimate in Hobbes's view because he saw natural philosophy as a mixed-mathematical discipline. Furthermore, because of their status as maker's knowledge

these principles transfer certainty to these explanations in natural philosophy. Although these natural-philosophical explanations do not carry the full certainty ascribed to demonstrations in geometry, insofar as Hobbes holds that we cannot know whether the causes that supposed (e.g., of the simple circular motion of the sun) are the "actually the causes of things [*causas rerum ... revera*]" (OL I.531), they are not merely "good guesses" about the causes of things, *pace* Martinich (2005, 174). Since we have maker's knowledge of these causal principles, we can be certain that *if* natural bodies behaved in the manner supposed then the behavior consequent from that type of motion necessarily follows. In the end, the causal claims in Hobbesian natural philosophy have an epistemic standing that is between the full certainty of geometrical demonstrations and the limited prudence that characterizes individuals who have no causal knowledge and rely solely on memory and associations.

6.0 HUMAN SCIENCE AND POLITICS

> For man is not just a natural body [*corpus naturale*], but also part of the state, or (as I put it) of the body politic [*corporis politico*]; for that reason he had to be considered as both man and citizen, that is, the farthest [principles] of physics [*ultima physicae*] had to be conjoined with the principles of politics, the most difficult with the easiest.
> Dedicatory letter to William Cavendish, *De homine*

6.1 INTRODUCTION

How Hobbes's natural philosophy, human science, and political philosophy are related to each other has been discussed in the literature for some time. Given its prominence, most of the discussions on these relationships have concerned the status of Hobbes's politics. As we have seen, some have argued that Hobbes is what I call a "deductivist" about politics, wherein there are deductive connections from first philosophy to natural philosophy and ultimately to politics.[143] Others have argued that Hobbes's politics is *sui generis*.[144] The relationship between Parts I and II of *Leviathan* (1651) has been a point of focus, but so has the relationship between

[143] Hampton 1986; Martinich 2005, 172-174; Peters 1967; Schapin & Schaffer 1985; Talaska 1988; Watkins 1973. Some who hold the deductivist view also advocate that Hobbes is a reductionist (esp. Hampton 1986).
[144] Robertson 1886; Sorrel 1986; Taylor 1938; Warrender 1957.

the two parts of *Elements of Law* (manuscript c. 1640) and the relationship between *De cive* (1642) and *De homine* (1658).

In this chapter, I use two under-appreciated aspects of Hobbes's philosophy to put this relationship between natural philosophy and politics in new perspective—that Hobbes saw maker's knowledge as the epistemic ideal for *scientia* and that he viewed mixed mathematics as providing the model for how disciplines like politics and human science are related to one another.[145] My account of the politics in this chapter thus denies the deductivist view while still holding that human science and politics are integrally related to one another—they are related to one another like geometry and natural philosophy are related to one another.

I argue that human science treats humans *qua* natural bodies in the state of nature where human body functions as 'point' does in geometry and where the passions function like 'motion'. Human science treats humans mathematically by abstracting away the characteristics that apply to them *qua* citizens. One can use the abstract causal principles learned in the state of nature when treating humans *qua* citizens not because of a deduction between the two sciences, but because in politics one mixes the abstract characteristics of humans *qua* natural bodies with those unique to humans *qua* citizens, just like one can mix geometrical principles in natural philosophy with characteristics peculiar to certain bodies. Seeing this connection between abstract and mixed disciplines illuminates why Hobbes uses thought experiments with a similar structure in two seemingly divergent areas—the state of nature in human science and the annihilation of the world in geometry.

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[145] I develop Hobbes's account of maker's knowledge in chapter 3 and his relationship to the mixed mathematics tradition in chapter 4, and I now apply the insights from these chapters to Hobbes's human science and politics.

6.2 HUMANS CONSIDERED AS NATURAL BODIES

Not everything that Hobbes included in the three volumes of *The Elements of Philosophy—De corpore*, *De homine*, and *De cive*—is relevant to things treated elsewhere. The use of the geometry from *De corpore* part III in *De corpore* part IV is explicit, but some chapters appear to have been included simply so that Hobbes could demonstrate the comprehensiveness of his mechanical philosophy. His discussion of the balance in *De corpore* 23 appears to be included for this reason. Something similar occurs in his discussions of the passions in the first section of *The Elements of Law*, the latter chapters of *De homine*, and *Leviathan* 6. There he offers what he took to be a *compete treatment* of the passions, but not all of the passions discussed are relevant to later chapters in the human science of Part I of *Leviathan* or in the politics of Part II.

Thus, Hobbes has two goals in discussing the passions. First, he provides a complete account of human passions that follows from his mechanical account of the human being.[146] Second, he highlights certain passions, what I call the driving passions (*fear* of death, *desire* of things necessary for commodious living, and the *hope* of attaining those things), by abstracting away all other passions so that in the state of nature thought experiment he can make what he calls an "inference" from the passions to the condition of humans outside of society—humans

[146] Gert argues that Hobbes's account of the passions is "almost completely independent of his mechanism" (1967, 503) because of its reliance upon introspection. However, Hobbes certainly sees introspection as consistent with a mechanical causal explanation (e.g., his imperative to "read thyself" in the preface of *Leviathan*; cf. EW III.xi-xii), but his appeal to introspection in the case of the passions should be taken as a *causal explanation*, especially given the clearly causal account of the passions in terms of motion, sensation, and conceptions in *Elements of Law*. Beyond these considerations, with its reliance about analysis and synthesis, any causal explanation will be a form of introspection upon one's own conceptions anyway, so it is unclear what Gert (1967) intends by this firm distinction between introspection and mechanism.

considered as natural bodies (*Leviathan* XIII; EW III.114). I discuss these two goals in turn in the following subsections.

6.2.1 *Leviathan* Part I versus Hobbes's Other Works

Many have taken Hobbes's *Leviathan* to be his definitive work in political philosophy, not only because it was written last among Hobbes's political works but also because 17 years later Hobbes took the trouble to revise it and translate it into Latin (1668). The *Leviathan* certainly contains Hobbes's most mature political philosophy; however, the *Leviathan* is not the only relevant text for determining Hobbes's views on the relationship between human science and politics. In addition to *Leviathan*, I examine *De homine* (1658), the delayed publication of which is a common topic in the correspondence,[147] for clues about Hobbes's thoughts on how natural philosophy, human science, and politics are related to one another.[148] While there are certainly differences between these works, as well as between them and the *Elements of Law*, my focus will be on the general points of agreement between them all on the *relationship between human science and politics*. Hobbes distinguishes between these two disciplines in all of his political works.

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[147] du Verdus to Hobbes (17/27 August 1656; Hobbes 1994c, 298, 299); Sorbière to Hobbes (13/23 December 1656; Hobbes 1994c, 388, 391); du Verdus to Hobbes (17/27 May 1657; Hobbes 1994c, 468, 471); Fermat to Hobbes (5/15 June 1657; Hobbes 1994c, 474, 475); de Martel to Hobbes (29 July/8 August 1657; Hobbes 1994c, 480, 482); and de Martel to Hobbes (7/17 August 1657; Hobbes 1994c, 483, 484).

[148] The relationship among these works is complicated. *De cive* was published first (1642) and then *Leviathan* (1651). Hobbes published *De homine* (1658) later, but even though some of the content of what he includes in *De homine* overlaps with his earlier works, the fact that it is published 7 years after the *Leviathan* is important, for in *De homine* we see Hobbes fitting "human science" within his larger structure in a way that he is unconcerned to do in the earlier *Leviathan*.

Rather than being a work that investigates politics exclusively, the *Leviathan* was written in English as a stand-alone volume[149] that covers topics as far-ranging as speech (chapter 1), imagination (chapter 2), and the taxonomy of knowledge (chapter 9), among others. These chapters from *Leviathan* Part I are all either material drawn from Hobbes's other works that were in progress when he wrote *Leviathan* or material that was developed further in the context of *Elements of Philosophy*.[150] Hobbes is explicit in *Leviathan* chapter I that treating these borrowed subjects is not his primary goal:

> To know the natural cause of sense is not very necessary to the business now in hand, and I have elsewhere written of the same at large. Nevertheless, to fill each part of my present method, I will briefly deliver the same in this place (EW III.1).

Hobbes treats general cause of all sensation in detail in *De corpore* 25. There he provides, as I have argued in chapter 5, a mixed-mathematical explanation wherein we can know the cause of sensation because we borrow principles from geometry (three principles from earlier in *De corpore*). Maker's knowledge from geometry thus provides causal knowledge for use in natural philosophy.

The definitions in *Leviathan* Part I are thus not merely stipulated definitions. They are not, *pace* Martinich, simply "technical definitions" whereby Hobbes informs the reader that "he will use a word in a particular way" (Martinich 2005, 148). Instead, these definitions depend upon causal inquiries achieved in other areas where their full explanation was the primary focus. Hobbes's insistence to provide these definitions in *Leviathan*, even if he does not provide the full

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[149] Martinich (2002, 45) calls *Leviathan* the Bible for the common man because of its comprehensive nature.
[150] Although Hobbes published *De corpore* (1655) and *De homine* (1658) years after he published *Leviathan*, Hobbes had been working on topics in natural philosophy before he published *Leviathan* (1651) and *De cive* (1642) (cf. the Review and Conclusion in *Leviathan*, EW III.714, Hobbes 1994b, 497; also the preface of *De cive* [Hobbes 1983, 35-36]).

causal inquiry of which they are the results, shows his commitment to the reliance of politics upon natural philosophy and human science.

6.2.2 A Complete Account of the Passions

6.2.2.1 *Elements of Law*

Hobbes's earliest treatment of the passions is in the first section of *Elements of Law*, called *Humane Nature*.[151] Chapters VII-VIII of *Humane Nature* articulate the connection of the passions to conceptions. Conceptions are motions in the brain, and when those motions continue to the heart they are called passions (Hobbes 1650, 77).[152] Passions, as types of appetite and aversion, are endeavours (Hobbes 1650, 70-71). Considered as motions, passions can either help or hinder the body's vital motion; when they help this vital motion it is called "delight" or "pleasure," but when they hinder the vital motion then they are called "pain" (Hobbes 1650, 69-70). These passions, which arise from conceptions, are responsible for animal motion—they are the "endeavour or internal beginning of animal motion" (Hobbes 1650, 71).

Given this intimate connection between conceptions and the passions arising when motion continues from the brain to the heart, Hobbes proceeds in chapter VIII to "search out and declare from what conception proceedeth every one of those passions which we commonly take notice of" (Hobbes 1650, 77). Chapter IX is thus concerned with an exposition of the passions, and chapter X continues this discussion by examining how individuals have different dominant

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[151] The *Elements of Law* was written around 1640 in two parts, *Humane Nature* and *De corpore politico*, and was published, without Hobbes's consent, in 1650.

[152] The account in *Elements of Law* differs from *De corpore,* where the heart is responsible for the outward motion in *both* conceptions and passions (e.g., *De corpore* 29.1, OL I.396). However, in *Elements of Law* the heart is involved only in the outward motions of the passions and "conception is nothing but motion within the head" (EL VII.1).

passions and how such passions, each with their own end, can lead to madness, excess in living, and the like. For example, when the passion of curiosity has "too much equality" then one will be distracted from "serious discourse" and have one's mind "diverted to every little jest, or witty observation" that comes to mind (1650, 125).[153]

Tönnies (1928, vii) suggests that with its early composition date (c. 1640) the *Elements of Law* was written "independently from and without any regard to the systematic plan," but there is a great deal of connection between the early work of the *Elements of Law* and the later work of the *Leviathan* and *De homine*, even if this work was done outside of Hobbes's considerations larger system.[154] For example, in the second part of *Elements of Law* (*De corpore politico*) Hobbes explicitly, even if briefly, acknowledges the dependence of the second part upon the first (1650, 2). Even still, Tönnies (1928, vi-vii) is certainly correct to note significant differences between *Elements of Law* and *De homine*, not the least of which is Hobbes's inclusion of optics in *De homine* and not in *Elements of Law*.

By the time of the English edition of *Leviathan* (and later in *De homine*, as well), we find Hobbes making no direct connection of the passions to conceptions.[155] There is certainly discussion of conceptions in *Leviathan*, but it is focused on sensation (EW III.1), understanding (EW III.11), our ability to conceive of the infinite (EW III.17), and names (EWIII.20, 26, 28). Given Hobbes's extensive discussion of conceptions generally and their connection to the passions in *Elements of Law*, this may come as a surprise. However, I suggest that this absence is explained by Hobbes's treatment of only those subjects in *Leviathan* that are *most* relevant to the

[153] Curiosity plays a key role for Hobbes in explaining humans' uniqueness. Tabb (forthcoming) argues that for Hobbes curiosity is the source of scientific activity and is ultimately responsible for the advent of language.
[154] On the sources of Hobbes's views of the passions, see Pacchi (1987).
[155] Hobbes does connect the motion from objects that is continued in sensation and imagination with the passions in *Leviathan* VI (EW III.38, Hobbes 1994b, 27) and in *De homine* XI.2 (Hobbes 1994a, 45), but he does so without mentioning conceptions as the intermediaries, though he does briefly connect them with phantasms in *De homine* XII.1 (Hobbes 1994a, 55) and the language of conceiving (*concipere*) is used in XII.

politics. This general sentiment runs throughout Hobbes's works, expressed in *Elements of Law* when he says that the "[...] minute and distinct anatomy of the powers of the body is nothing necessary to the present purpose" (1650, 4). Similarly, the theoretical account that connects the passions to conceptions is not germane to the more mature human science and politics in *Leviathan* and *De homine*.

6.2.2.2 Complete Account of the Passions: *De homine* and *Leviathan*

The structure of *De homine* and its relationship with *De corpore* and *De cive* has long puzzled Hobbes scholars. Some have argued that it was merely a hodgepodge of sorts that Hobbes cobbled together of existing materials with the goal of simply completing the *Elements of Philosophy*, since it was really merely "second thoughts about issues already discussed in the [other] two sections" of the *Elements* (Martinich 1999, 278). Hobbes's inclusion of the material on optics in *De homine* chapters 2-9 is perhaps the most puzzling feature of the book, for reasons that I will discuss momentarily.

Hobbes clearly thought that the material in *De corpore* that related to human beings also related to living animals more generally. For example, Hobbes's discussion of the general cause of sensation in *De corpore* 25 applies to all living animals and not to humans alone. So Hobbes argues in *De corpore* 25.3 that "it is more proper when we say that the animal sees than the eye [*animal videre quam oculum rectius dicimus*]" (OL I.319). Moreover, in *De corpore* 25.13 Hobbes explains that he has delayed discussion of the passions until *De homine* because, even if animals do have passions, "many [passions] are not visible [*inconspicuae*] except in human beings" (OL I.334).

Given that Hobbes's treatment of sensation generally in *De corpore* 25, as well as the treatment of sound, odor, taste, touch in *De corpore* 29, is supposed to apply to all living animals

and not merely to human beings, it is strange that Hobbes includes the optical material on vision in *De homine*, as if it applied only to human beings (see discussion in Martinich 1999, 278). Most others working in optics would not have held this, e.g., Descartes discussion of using an ox's eye in the *Dioptrics* (cf. AT VI.115). However, I wish to leave this issue to the side and return our attention to Hobbes's discussion of the passions in *De homine*.

In *De homine*, appetite and aversion are the primary drives in humans—they are the motions that incline humans to do one action over another. The passions (or emotions, as Hobbes also calls them in *De homine*) are kinds (*species*) of appetite and aversion (1658, 67). Hobbes discusses appetite and aversion generally in *De homine* XI and expounds upon particular passions in XII. Appetite and aversion are types of delight (*jucunda*) and offensive reaction (*molesta*),[156] but they differ from delight and offense in that they are not caused by something currently present—they relate to foreseen or anticipated (*praeviso aut expectato*) delight or offense (1658, 61). One feels aversion to something not currently experienced because one foresees one's offense if that experience were to occur in the future.

Like in the *Elements of Law*, in *De homine* XI Hobbes characterizes appetite and aversion (and likewise the passions) in terms of endeavour (*conatus*), or motion too small to be measured (1658, 61). However, in *De homine* he contrasts this type of endeavour with sensation:

> "...delight and [offense], although they are not called senses, nevertheless differ only in this: that the sense of an object, as external, comes from the reaction or resistance that is made by an organ; and hence consists in the endeavour [*conatus*] of an organ to push outward; delight, however, consists in the passion made by the action of an object, and is an endeavour inwards" (Hobbes 1994a, 45).

[156] I have translated *molesta* as 'offensive' instead of 'annoyance', as Gert does (cf. Gert's translation, 1994a, 45), in order to keep with Hobbes's own translation of *molesta* in *Leviathan* (cf. EW III.42).

The outward endeavour caused by the reaction or resistance of our body against the motion coming from an external object explains why we perceive objects outside of us as external. The inward endeavor explains our appetite or aversion for certain experiences or objects.

Hobbes portrays the passions as "perturbations of the mind" (*perturbationis animi*) in *De homine* XII. He intends the negative connotation associated with 'perturbation', for he says that they "frequently obstruct right reasoning" (Hobbes 1994a, 55). The passions obstruct right reasoning by often failing to "foresee the greater evils that necessarily attach" to a given action; by 'right reason' we should understand Hobbes to be referring to drawing out the consequences of a given conception, characterized by analysis and synthesis, already discussed in chapters 2 and 3. What follows in *De homine* XII is a catalogue of sorts of the passions: joy, hate, hope, fear, anger, and pride, among others. He closes the chapter by noting "[t]here would be an almost infinite number of passions [*passionum*], if we gave different names to them all [...] since none there be that are not related to some one of those that we have described, we shall be content with what we have said concerning them" (Hobbes 1994a, 62).

This interrelation of some passions to others, where the passions Hobbes discusses are related to others left unmentioned, is further clarified in *Leviathan* where Hobbes introduces what he calls "simple passions." Like in *De homine* and *Elements of Law*, in *Leviathan* VI Hobbes connects his discussion of the passions to motion, differentiating his view from those in the Schools who, though they acknowledge that there is motion involved in them, "call it metaphorical motion" (EW III.39-40). Hobbes thinks that such a claim is "absurd" since only words can be metaphorical, not "bodies or motions" (and thus not the passions caused by endeavour) (EW III.40).

As he does in *De homine*, Hobbes distinguishes between what he calls the pleasures of sense and the pleasures of the mind in *Leviathan*; those of sense "arise from the sense of an object present," and those of the mind are from "foresight of the end, or consequences of things" (EW III.42-43). Hobbes then provides what he calls "simple passions": appetite, desire, love, aversion, hate, joy, and grief (EW III.43). By showing how these simple passions combine together, he is able to give an account of a wide range of more complex passions, such as fear, hope, despair, benevolence, and confidence. But even these simple passions, as simples, are related to one another. For example, Hobbes notes that even though the simple passions appetite and desire are sometimes used interchangeably, desire is the "general name" and appetite is "oftentimes restrained to signify the desire of food, namely hunger and thirst" (EW III.39). So even though 'desire' and 'appetite' are both considered as "simple passions" out of which other more complex passions are formed, 'desire' is related to 'appetite' as genus to species.

These simple passions have their names for various reasons, and so do the more complex passions that result from their combinations. Hobbes provides four such reasons: first, when one passion follows another they are "called from the opinion men have of the likelihood of attaining what they desire"; second, "from the object loved or hated"; third, when there are many of these simple passions occurring together; and fourth, when there is a particular succession or alteration of passions (EW III.43). For example, we have the passion 'hope' when there is an appetite for some object or end and additionally there is "an opinion of attaining" it (EW III.43). Similarly, 'fear' occurs when we have aversion "with the opinion of hurt from the object", and when there is hope that we can avoid that hurt we have 'courage' (EW III.43).

6.2.3 Making an "Inference from the Passions" to the State of Nature

Although briefer than the treatment of the passions in *Elements of Law* and *De homine*, the account of the passions in *Leviathan* is dependent on the more complete work elsewhere. As Hobbes notes regarding his account of sensation in *Leviathan* I, already mentioned, I suggest that his treatment of the passions in the *Leviathan* is focused upon what will be useful for his account of the construction of the commonwealth and for politics generally. This focus for his discussion of the passions is evident from his description in *Leviathan* XIII of the "inference" made from the passions to the state of nature:

> It may seem strange to some man, that has not well weighed these things; that nature should thus dissociate, and render men apt to invade, and destroy one another: and he may therefore, not trusting *this inference*, *made from the passions*, desire perhaps to have the same confirmed by experience (EW III.113-114; emphasis added).

Hobbes's statement about confirming "by experience" this inference made from the passions relates to his view about the relationship between civil philosophy and moral philosophy expressed in *De corpore* 6.7.[157] There he claims that these two *may* be separated, "for the causes of the motions of minds are known [*cognoscuntur*] not only by ratiocination, but also by the experience [*experientia*] of each one observing his own motions in himself" (OL I.65).

Rather than taking this discussion in *De corpore* 6.7 as evidence that Hobbes's political philosophy is *disjoined* from his account of the passions, and as a result disjoined from his

[157] By 'moral philosophy' here in *De corpore* 6.7, Hobbes means what I call 'human science', i.e., the science of human passions wherein humans are treated as natural bodies considered apart from civil society. Hobbes also refers to ethics, sometimes using it in place of moral philosophy (cf. *De corpore* 1.9, OL I.10), as what is studied as the "consequences of the passions" in the table of the sciences in *Leviathan* IX (EW III.73).

natural philosophy, I argue, *pace* Robertson (1886), Sorrel (1986), Taylor (1938), and Warrender (1957), that Hobbes's reference to experience of the motions of one's own mind in *De corpore* 6.7 and in *Leviathan* XIII, quoted above, suggests that this sort of experience is merely a way of *confirming* what is known better by making an inference from the passions, known better since it is *scientia*. This inference from the passions is preferred because by constructing from the state of nature a person has maker's knowledge and thus has *scientia* of the principles of the commonwealth (more on this below).

Such a reading receives further support from Hobbes's own distinction later in *De corpore* 6.7 between what can be known by the synthetic method in compounding from "the earlier part of philosophy"—physics and geometry—and what can be known by those who rely only on their experience of the motions of their mind. Whereas Hobbes uses '*cognitio*' and its cognates to describe the knowledge attained from experience of one's own mind, he reserves *scientia* only for those who know by compounding in synthesis. In synthesis, he argues that one discovers that the "principles of politics consist of knowledge [*cognitione*] of the motions of minds" but that "the knowledge [*cognitio*] of the motions of minds, however, consists of knowledge [*scientia*] of the senses and cognitions" (OL I.65).[158]

Hobbes later uses *cognoscere* to refer to an example of what one can know by means of one's own experience: "...one ... arrives at the fact that the appetites of men and the motions of their minds are such that they will wage war against each other unless controlled by some power. This fact *can be known* [*cognosci potest*] by the experience of each and every person who examines his own mind" (Hobbes 1981, 303; cf. OL I.66). Although it is possible to reach the

[158] Martinich (Hobbes 1981, 302-303) translates *constant* as "depend upon". I have translated *constant* as 'consist' in keeping with Hobbes's other uses of the term in *De corpore* (e.g., OL I.156, OL I.255, OL I.319, and OL I.334); doing so makes this a claim about the content of the principles and not a matter of dependence of one upon another.

same conclusions by compounding in synthesis and by examining the motions of one's own mind, Hobbes accords *scientia* only to the conclusion arrived at by compounding in synthesis; this, I suggest, is because synthesis and compounding give maker's knowledge. Examining the motions of one's own mind merely provides additional confirmation of what is established in compounding.

So what exactly is this "inference" from the passions that Hobbes claims to make in *Leviathan* XIII? The basic idea, which I will further elaborate below, is that after his complete treatment of the passions in *Leviathan* VI, Hobbes considers in chapter XIII the passions that emerge as dominant when humans are considered merely as natural bodies in the state of nature. There humans are considered as completely apart from organized civil society, though in the state of nature there are some interpersonal relations between individuals.[159] Three driving passions are identified at the end of the state of nature thought experiment, in the final section of chapter XIII. There Hobbes identifies them as passions that incline humans toward peace: "... fear of death; desire of such things as are necessary to commodious living; and a hope by ... industry to attain them" (EW III.116). I call these driving passions to represent their foundational status in the state of nature thought experiment and in the construction of the commonwealth.

In what remains of this section, I argue that the state of nature thought experiment is a device that allows Hobbes to show that these three driving passions remain and are the driving

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[159] Macpherson (1962, 17ff) argues that humans in the state of nature are not outside of *all* society; instead, Macpherson argues that for Hobbes to be able to make a "deduction" from "man as a mechanical system" to the state of nature to work there must be additional assumptions in place, specifically assumptions about "relations prevailing between men in a certain kind of society." The kind of society Macpherson has is in mind is Hobbes's own society and how those in it would act if there were no sovereign power to enforce the covenant (cf. esp. Macpherson 1962, 22). I have argued that Hobbes is not providing a deduction; furthermore, while Macpherson is certainly correct that even though Hobbes saw his state of nature as "universally valid" his conception of human nature was tied to his social setting. My goal is to show how Hobbes saw the relationship between human science and politics to work, even if, as a matter of fact, his account of humans in the state of nature is, perhaps unsurprisingly, indebted to his *sitz im leben*.

inclinations in such a situation. I show that these driving passions in the state of nature experiment function analogously to what is left for the human who remains even after the annihilation of the world thought experiment in *De corpore* VII. Furthermore, I argue that, although many have claimed that the passion 'fear', and with it self-interest, dominates in Hobbes' account of the passionate inclination toward peace (and have thus seen Hobbes as a sort of egoist concerned primarily, if not entirely, with self-preservation),[160] in *Leviathan* Hobbes held that these three driving passions all drive humans toward peace in the state of nature.

6.2.3.1 Driving Passions and Humans outside of Society

Leviathan Chapter XIII is concerned mostly with the so-called state of nature, which Hobbes refers to as the "natural condition of mankind" (EW III.110). Whereas in the annihilation of the world thought experiment in *De corpore* 7, where the reader is told to imagine all the bodies in the world to have been annihilated, the reader of *Leviathan* is asked to imagine the natural state of humans as a situation in which people "live without a common power to keep them all in awe" (EW III.112-113).[161] As in the case of the annihilation of the world, Hobbes admits in the case of the state of nature that "there was never such a time, nor condition of war as this," at least not "generally so, over all the world" (EW III.114).[162]

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[160] The view that Hobbes is a psychological egoist of some sort has prevailed since the 18th century with Joseph Butler's sermons on human nature; however, this view has, in recent scholarship, been less prevalent (for discussion, see Gert 1996).

[161] Patricia Springborg (2008, 683) notes that Hobbes's usage of a thought experiment in *Leviathan* is paradoxical given his philosophical psychology.

[162] Hobbes adds that even though such a general state of nature never existed, "it may be perceived what manner of life there would be" in such a case by looking at particular instances, e.g., the "savage peoples in many places of America" and also the "posture of war" that exists between the sovereigns of countries (EW III.114-115). Something similar could be said for the feigned annihilation of the world, since we have had the experience of particular phantasms remaining after the bodies causing them were absent even if we have never experienced the complete annihilation of the world.

Like in the annihilation of the world thought experiment, where bodies and their motions are considered in abstract and irrespective of their particular and differentiating qualities, in the state of nature thought experiment humans are imagined to be wholly outside of civil society.[163] Considered apart from their various societal positions, which in a commonwealth would be regulated by a sovereign and the government in place around the sovereign, humans are all equal by nature (EW III.110).This *equality* is the most basic conception that arises when imagining humans as apart from civil society; it plays a role similar to the conception SPACE that is the simplest conception that arises from any experience of bodies (discussed in chapter 3; cf. OL I.82). This equality exists in both the faculties of body and mind: Each person, weak or strong, has the ability to kill any other person, even a stronger person whether by "secret machination" or by "confederacy with others." Likewise, each person with the same amount of experience has equal prudence since "prudence is but experience" (EW III.110).

Equality in bodily and mental abilities gives rise to everyone in the state of nature having an "equality of hope in attaining our ends" (EW III.111). This 'hope' in attaining one's ends is the same hope mentioned later in Chapter XIII as one of the passions that inclines toward peace (cf. EW III.116)—the hope that by one's industry one will be able to attain the things necessary for commodious living. The equality present between humans in their natural state is the cause of each person in the state of nature having the driving passion of hope to attain his or her ends. A wide range of things is included as part of commodious living, described negatively as what is *absent* in the state of nature:

> In such a condition, there is no place for industry; because the fruit thereof is uncertain: and consequently no culture of the earth; no navigation, nor use of the

[163] Martinich (2002, 76-77) argues there are two states of nature: the primary state of nature abstracts away the laws of nature, and the secondary state adds the laws of nature by composition.

> commodities that may be imported by sea; no commodious building; no instruments of moving, and removing, such things as require much force; no knowledge of the face of the earth; no account of time; no arts; no letters; no society; and which is worst of all, continual fear, and danger of violent death; and the life of man, solitary, poor, nasty, brutish, and short (EW III.113).

Although the "continual fear" in which humans in such a condition live is the *worst* aspect of humans' natural state, this continual fear is not the *only* passion driving humans toward peace in the state of nature. Hobbes does not provide an argument in support of the claim that each person in the state of nature has the desire for things that are necessary for commodious living (another of what I call driving passions); he simply states this as something that would be seen by anyone entertaining the thought experiment.[164] Instead he assumes that each person desires these things; the hope that each person possesses (another driving passion) that he or she can attain those things by industry is caused by the equality among persons in the natural state of humans.

So far in the thought experiment, Hobbes has had the reader imagine the state of nature as a situation characterized by the absence of all societal standing, even though there are some interpersonal relations. Each person is equal to every other person in terms of his or her bodily and mental abilities. Although Hobbes does not explicitly mention it, these individuals each desire whatever is necessary for commodious living.[165] The equality shared among those in the

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[164] In the introduction to *Leviathan*, Hobbes distinguishes between the "similitude of *passions*" and the "similitude of the *objects* of the passions" (EW III.xi), arguing that humans are similar in having the same passions, such as desire, fear, and hope, even if each person may have a different object for those passions. Nevertheless, he holds in the state of nature thought experiment that the things necessary for commodious living are a universally held class of objects which are desired. This does, of course, still leave room for each individual to desire different objects which are seen to that individual as necessary for commodious living.

[165] It is unsurprising that Hobbes would not argue for this because 'hope' is really just an appetite with the *opinion* that one may obtain the thing desired (cf. EW III.43). So saying that one has hope is just to say that one believes that one's desire is likely to be achieved. Thus, holding that equality among those in the state of nature causes hope is equivalent to saying that equality causes this desire with an *opinion* that one is likely to achieve what one desires.

state of nature causes each of them to have the driving passion of 'hope'. Importantly, so far in the thought experiment there has not yet been any discussion of the driving passion *fear*.

The driving passion of fear arises in the state of nature when "any two men desire the same thing, which nevertheless they cannot both enjoy" (EW III.111). In such a case, these two individuals become enemies because one blocks the other from being able to attain something necessary for self-preservation or something perceived as necessary for pleasure, or as Hobbes puts it something for "delectation only" (EW III.111). One might argue that a scarcity or at least a limited supply of the goods desired, whether for survival or pleasure, is a precondition for the state of nature thought experiment, as Wolff (2006, 10ff) does. However, neither scarcity nor limited supply is required, for all that is needed to cause *fear* to arise is for one individual simply to want *all* of a given item and another individual want to have some number of that item, e.g., someone could desire to have every tree of a certain kind even if there were hundreds or thousands available while another may want only one of that kind of tree.

Following the complete account of the passions in *Leviathan* VI, only these three driving passions emerge in the state of nature thought experiment in Chapter XIII. We should not understood Hobbes as claiming that individuals in the state of nature actually have (if they ever so existed) *only* these three driving passions and no other passions. Instead, when all qualities relating to human society are abstracted away, these three passions remain as *the driving passions that incline humans toward peace*. These passions are the dominant passions that overpower any other passions that are present; even in the presence of other passions, these three explain why humans seek peace and move toward forming civil society. Like the simplest conception SPACE in the annihilation of the world thought experiment (and the simplest conceptions BODY and MOTION), these driving passions are epistemic simples. They do not

exist as simples in the world (cf. OL I.22). There are no humans who exist with *only* these three driving passions.

A useful way of comparing the state of nature thought experiment with the annihilation of the world thought experiment in *De corpore* 7 is to consider what counts as the *starting point* for each. In each thought experiment, Hobbes begins at a different level which serves as a starting point for the inquiry at hand. For the annihilation of the world thought experiment the starting point is the simplest conceptions of BODY and MOTION, i.e., simple bodies moving according to simple motions. Hobbes proceeds from these most fundamental "simplest conceptions" to the other conceptions in first philosophy.

However, in the state of nature thought experiment, the starting point for the thought experiment is at a less abstract level. Here we see that the structure of Hobbes's sciences is not one of *logical* dependency but rather of levels of abstraction.[166] Human beings outside of society function in a way similar to how BODY functions in the annihilation of the world thought experiment and the three driving passions function like MOTION. The conclusion to the 1650 edition of *Elements of Law* provides support for seeing humans in the state of nature functioning as the *simples* for *that discipline* and not as simples absolutely: "Thus we have considered the nature of Man so far as was requisite for the finding out the first and most simple elements wherein the compositions of Politick Rules and Laws are lastly resolved ..." (1650, 170).

The connection between the three driving passions in the state of nature and the simplest conception MOTION in first philosophy is further supported by Hobbes's view that the passions

[166] Human science is at a *less-abstract* level than geometry or first philosophy, but it is *more abstract* than political philosophy. Since only bodies exist in Hobbes's world, the relationship between these sciences can be characterized as being between differing levels of abstraction. Macpherson (1962, 21) characterizes the state of nature as a "logical hypothesis," by which he means that it is a "condition logically prior" to the establishment of a commonwealth. However, Macpherson's characterization of the move from human science to politics as a logical "deduction" misses the strong similarities between this move and all the other moves between sciences in Hobbes's philosophy.

are types of motion that *move* humans toward one action over another. Hobbes's desire to avoid every sense of the "metaphorical motion" of the Schools holds in the state of nature thought experiment just as well as it holds in Chapter VI where he treats passions exhaustively. It is thus unsurprising that in this context, Hobbes uses the term that he does when he says that these three driving passions "incline men to peace" (EW III.116).

6.2.3.2 How the Driving Passions are Related to One Another

The passion fear plays a more central role in inclining humans toward peace in *De cive* than it does in *Leviathan*. Indeed, Hobbes is explicit that fear is responsible for the institution of "mutall society." His claim in *De cive* that we "... doe not by nature seek Society for its own sake, but that we may receive some Honour or Profit from it [...]" (Hobbes 1983b, 42) still resounds in the *Leviathan*. However, in *De cive* he expresses that, although there may be other passions which drive humans toward the peace that may be found in civil society, without *fear* they would merely seek dominion over others: "[...] I hope no body will doubt but that men would much more greedily be carryed by Nature, *if all fear were removed*, to obtain Dominion, then gaine Society" (Hobbes 1983b, 44; emphasis added). Furthermore, Hobbes clearly holds in *De cive* that the motivation for creating civil society is self-directed and not other-directed (more on this distinction below): "All Society therefore is either for Gain, or for Glory; (*i.e.*) not so much for love of our Fellowes, as for love of our Selves [...]" (Hobbes 1983b, 43). Although my focus is upon the passions that drive humans to seek peace in civil society, it is worth noting that

in *De cive* fear is also the passion which holds society together and restrains humans "through feare of some coercive power" (Hobbes 1983b, 32).[167]

In the *Leviathan* the driving passion fear certainly plays a role in the state of nature as part of what inclines humans to seek peace and form civil society, but I contend that the role it plays is tempered by the two other-directed driving passions which I have identified: desire for commodious living and hope of attaining commodious living by joint industry. In addition to these driving passions, greater concern for and involvement of *others* characterizes Hobbes's view of the passions in *Leviathan* when compared with his earlier works.[168] I call these passions "other-directed" not because they require the demonstration of concern for others without regard for oneself. Instead, they are other-directed because for their fulfillment they require the cooperation of others. For example, one simply cannot have commodities that are imported by ship without others' cooperation. Love is another example. These other-directed driving passions are distinguished from the fear of death since assuaging fear of death does not *require* the cooperation of others insofar as it could also be alleviated by killing those others whom one fears or by forcibly subjecting them to one's own power.

I do not deny that the driving passion of fear of death may seem to have a sort of logical priority over the other two driving passions for Hobbes, but I contend that such a view is not Hobbes's view. One is unlikely to have a desire for the things seen as necessary for commodious living unless one no longer fears for one's life. One will not pine for fine Islay Scotch when fleeing from a murderer. Indeed, in Chapter XVII Hobbes appears to grant that the reason that

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[167] Gert (1967, 513) emphasizes that this is a claim about *groups* and how they must be regulated, which depends on the view that it is likely that there will be some in any group who will disrupt the peace, and not a claim about *all* humans.

[168] For example, Gert (1967, 509ff) cogently argues that from *Humane Nature* to *Leviathan* Hobbes's definitions of the passions shift away from "self-regarding" to showing more of a regard for others, e.g., the definition for pity.

humans in the state of nature allow themselves to be restrained is because they have the "foresight of their own preservation and of a more contented life *thereby* [...]" (EW III.153; emphasis added). By isolating this passage, to the exclusion of the passages which have thus far been my focus, one might hold that commodious living (part of what Hobbes means by 'a more contented life' here) is only an *indirect* consequence of humans' desire for self-preservation fueled primarily by their fear of death. Hobbes scholars have certainly emphasized the priority of the fear of death over all other passions as what drives humans out of the state of nature, and this has led many to see Hobbes as some sort of egoist, with many varieties of the egoist views attributed to him (cf. fn. 18).

However, I wish to emphasize that, although one may see a sort of logical priority of fear over the other two driving passions, if one gives weight to Hobbes's treatment of the driving passions in Chapter XIII *such a prioritization of one driving passion over the others is not licensed* by what Hobbes actually says. For in Chapter XIII Hobbes simply lists three driving passions as those which each incline humans toward peace. Given Hobbes's language there of *inclination* and his account elsewhere of the passions as *motion*, the picture that develops is that there are three different motions (fear of death, desire of things necessary for commodious living, and hope to gain those things by industry) each moving toward the same end—peace. One may be permitted to say that, given Hobbes's later comments in Chapter XVII, fear of death is a stronger, more forceful motion, but this should in no way detract from thinking that Hobbes held that the other two passions were also responsible for inclining toward peace. Hobbes seems ultimately unconcerned with issues of logical priority in explaining this inclination toward peace.

6.2.4 Reason and Persons

Hobbes addresses two additional topics in the human science of Part I that are relevant to the construction of the commonwealth in Chapter XVII—reason and persons. Both concern capabilities that humans outside of society possess, and so these capabilities are part of the consideration of human beings as *natural bodies*. However, they differ from the discussion of the passions in Chapter XIII because their role in the explanation of the commonwealth later in political science, where humans are considered as *citizens*, is that of *the means by which peace is accomplished*. The driving passions incline humans toward peace (they are the motions driving humans, considered as natural bodies, to seek peace), and reason and the ability to be someone else's representative, both present in the state of nature, are the means that enable these passions to be satisfied. My brief discussion of reason and persons will focus on their relationship to the driving passions.

The description of how reason and the passions are related to one another at the end of *Leviathan* Chapter XIII is initially puzzling given what Hobbes says later in Chapter XVII. In Chapter XIII he describes the driving passions as those which "incline men to peace" and then "reason suggesteth convenient articles of peace, upon which men may be drawn to agreement. These articles, are they, which otherwise are called the Laws of Nature [...]" (EW III.116). These articles that reason suggests are the focus of the two chapters that follow. However, in Chapter XVII Hobbes holds that the laws of nature "of themselves, without the terror of some power, to cause them to be observed, are *contrary to our natural passions*, that carry us to partiality, pride, revenge, and the like" (EW III.153-154; emphasis added). Rather than driving passions inclining humans in the state of nature toward peace, as in Chapter XIII, in Chapter XVII we find that the

"miserable condition of war" is "necessarily consequent [...] to the *natural passions of men*" (EW III.153; emphasis added).

For Hobbes the only thing that can redirect one's action away from the end driven by a given passion is *another passion*. Reason does not bridle the passions; instead, reason is merely a means-to-ends tool that humans use once they have already been driven toward peace by the three driving passions.[169] When humans have already been inclined toward peace, reason suggests the way to accomplish that peace. Thus, it is important to distinguish two distinct roles played by the passions in the formation of the commonwealth: first, there is the inclination toward peace when humans are in the state of nature; second, there is the need to keep people's individual passions at bay and have them abide by the terms of the covenant once they are in the commonwealth.

The first role of the passions in inclining humans who are in the state of nature toward peace is played by the three driving passions, which I have already discussed. In *Leviathan*, the second role is played exclusively by the passion of fear, as in *De cive*, which was already discussed. Reason and the passions conflict only when there is no absolute power "to keep them in awe" (EW III.153) and when there are things desired by more than one person. The absence of the passion of fear explains why covenants made outside of a commonwealth are void: "For he that performeth first, has no assurance that the other will perform after; because the bonds of words are too weak to bridle men's ambition, avarice, anger, and other passions, without the fear

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[169] Gert (1996, 171) claims that for Hobbes the passions are subservient to reason, citing only Hobbes's brief claim in *De cive* 7 that "for the natural state hath the same proportion to the civil (I mean liberty to subjection) which passion hath to reason, or a beast to a man" (cf. Hobbes 1983b, 116). However, this point is within a general discussion of "by what means it comes to pass that they [subjects] are releas'd from [...] bonds of obedience" (Hobbes 1983b, 116), and Hobbes's point is simply that reason plays the role of "subjection" to the passions only by showing humans in the state of nature how to find peace, namely by instituting a commonwealth with a sovereign that will afterwards give rise to the passion of fear and thus keep their other (conflicting) passions under control.

of some coercive power" (EW III.124). Reason and certain passions conflict only in the absence of the passion of fear of the sovereign.

A person's words and actions can be considered either as her own words or as representing those of another. *Leviathan* Chapter XVI is devoted to persons, authors, and the things that can be personated. The key distinction is between *natural persons* and *artificial persons*. A natural person is one whose actions and words are considered her own; an artificial person is one whose actions and words are "considered as representing the words and actions of another" (EW III.147).

Hobbes next distinguishes between *actors* and *authors*. An author is someone "who owneth his words and actions" (EW III.148). Actors are artificial persons because their words and actions are "owned by those whom they represent" (EW III.148); actors play roles such as representer or representative, lieutenant, vicar, attorney, and so on (EW III.148). When one authorizes an actor, the covenants which the actor makes on one's behalf bind one as if one had made those covenants oneself (EW III.148-149). In fact, for Hobbes when someone, say person A, authorizes an actor, say B, then A is bound when B acts because, in a strong sense, it is A who is acting since A has given over her authorization to B. As a result, A owns the actions in which B engages.[170]

So far Hobbes has shown how one person represents another, but how does a multitude of persons become one person such that the single person is the actor for all of them? There are two levels of becoming one person for Hobbes. First, a multitude can become one person by consent:

[170] This does not, of course, exclude B from acting outside of her representation of A; A's ownership of actions applies only when B is *acting on A's behalf* as an actor for A.

> A multitude of men, are made one person, they are by one man, or one person, represented; so that it be done with the *consent* of every one that multitude in particular (EW III.151).

Hobbes expands upon this last phrase in the Latin version of *Leviathan*: "it is represented by one who has authority from each one" (Hobbes 1994b, 104 fn. 7). However, the unity described here is mere consent and not a "real unity" because it is missing the conditional clause in which each person covenants with every other person.[171] A covenant is a type of contract in which one of the parties does his part and then "leave[s] the other to perform his part at some determinate time after" (EW III.121).

Let us revisit a question raised earlier regarding the division between human science and politics and provide an answer to this question in light of the discussion so far. Why does Hobbes place the "science of the just and unjust" under physics and not under politics in the table of the several subjects of science in *Leviathan* IX (EW III.72-73)? I argue that the science of the just and unjust is under physics and outside of politics because it concerns only the machinery—the mechanical procedures—necessary for there to be justice inside the commonwealth. They are the means-to-ends tools that humans use once their passions have driven them toward peace. For example, one must know *how to lay down a right* (EW III.118) apart from the commonwealth to be able to lay down one's right when making the commonwealth. Furthermore, before the commonwealth can be made, the machinery of contracting and covenanting must already available in the state of nature, as we find in *Leviathan* XIV (EW III.120-121).

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[171] Hobbes's account of 'union' in the *Elements of Law* is similar to what I call mere consent here. In *Elements of Law*, Hobbes's account lacks the action of each person entering into a conditional covenant with each other person. Instead, the covenant is only between each of the subjects and the sovereign, as in the following formulation: "The making of union consisteth in this, that every man by covenant oblige himself to some one and the same man, or to some one and the same council, by them all named and determined, to do those actions, which the said man or council shall command them to do, and to do no action, which he or they shall forbid, or command them not to do" (EW IV.121-122). This is what Hobbes says makes a union, or "a body politic" (EW IV.122).

Thus, there is a difference between the *science* of the just and unjust, which is under physics, and the *presence* of justice and unjustice, which occurs only when there is a sovereign in place. Hobbes is clear that there is no justice or injustice apart from a commonwealth:[172] "The desires, and other passions of man, are in themselves no sin. No more are the actions, that proceed from those passions, till they know a law that forbids them [...]" (EW III.114). However, all of the *machinery* available for creating justice when one institutes a commonwealth is available outside of the commonwealth. The science of this machinery is the science of the just and unjust, and Hobbes places it under physics on the table in *Leviathan* IX because learning how authorization happens is not different from learning how light rays refract inside the eye—the difference is only the type of body involved (human bodies versus light rays).

6.3 HUMANS AS CITIZENS

Hobbes famously claims that both political philosophy and geometry are demonstrable because we have *maker's knowledge* of the commonwealths and geometrical figures that we construct. In addition to political philosophy and geometry, I have argued in chapter 3 that individuals who construct from simplest conceptions also have maker's knowledge of the complex conceptions that they construct in first philosophy. Although it has been recognized generally by commentators that Hobbes held that individuals had maker's knowledge by constructing in geometry and political philosophy, little attention has been paid to the details of what is actually involved when a commonwealth is constructed.

[172] See Martinich (2002, 82-86) for an argument that the laws of nature are in force, and thus that there is justice, even in the state of nature (what Martinich calls the "secondary state of nature"). On my account, the laws of nature are means that reasons suggests for how justice *could be* present, since in the state of nature it is not present.

Some commentators have examined the steps of construction in *Leviathan*, but none has focused on the differences between making a commonwealth and making a geometrical figure.[173] Gauthier discusses the construction of the commonwealth but explicitly says that his goal is not to "pursue the details" since he seeks only to show that construction in political philosophy "exemplifies the ideal of [geometrical] demonstration that we have found in the *Six Lessons* and *De homine*" (Gauthier 1997, 519). But the details of the constructive steps that Hobbes provides in *Leviathan* are exactly where one should look to see how alike maker's knowledge in geometry is to maker's knowledge in political philosophy.

In this section, I focus on these differences between geometry and political philosophy. First, I examine Hobbes's appeal to a final cause in the construction of the commonwealth. Next, I consider who counts as the maker(s) of the commonwealth and the degree to which what happens with the commonwealth is analogous to geometrical construction. Then I look to the steps of commonwealth construction in *Leviathan* XVII and show how Hobbes treats the explanation of the creation of the commonwealth as a mixed mathematics explanation, where causal principles are borrowed from human science.

6.3.1 Final Causes in the Commonwealth and Not in Geometry

Focusing on commonwealth construction exposes that there are a number of prima facie dissimilarities between constructing a geometrical figure and constructing a commonwealth. The first difference is the appeal to a final cause to explain both the construction of the

[173] The few in the literature that have addressed this issue merely mention some of the apparent differences without attempting to resolve the issue. Child (1953, 281-282) and Sacksteder (1980, 144-146) mention dissimilarities only in passing in discussions tangentially related to this issue, and Gauthier (1997) does not address the differences between the geometrical and political contexts.

commonwealth in *Leviathan* XVII (EW III.153) and the particular rights of the sovereign in *Leviathan* XVIII (EW III.163-164) that follow as consequences from the sort of (artificial) body the commonwealth is. There is no appeal to a final cause in the account of maker's knowledge in geometry. Hobbes begins *Leviathan* chapter 17 by identifying the final cause of the commonweath:

> The final cause, end, or design of men, who naturally love liberty, and dominion over others, in the introduction of that restraint upon themselves, in which we see them live in commonwealths, is the foresight of their own preservation, and of a more contented life thereby; that is to say, of getting themselves out from that miserable condition of war, which is necessarily consequent, as hath been shown in chapter XIII, to the natural passions of men to keep them in awe, and tie them by fear of punishment to the performance of their covenants, and observation of those laws of nature set down in the fourteenth and fifteenth chapters (EW III.153).

This appeal to a final cause may seem strange since Hobbes is about to provide the generative steps for commonwealth construction. It may also seem strange since Hobbes rejects appealing to final causes elsewhere. However, he does grant in *De corpore* 10.7 that a final cause can be used when discussing things which have "sense and will" (*sensum et voluntatem*), but even this, he argues, will be shown to be an efficient cause (OL I.117).

Similarly, in *Decameron Physiologicum* 2, if we take Hobbes to be speaking through interlocutor B, Hobbes states that the final cause "hath place only in moral philosophy" (EW VII.82). Commentators have been divided on how to handle this brief mention of final causes and moral philosophy in *Decameron Physiologicum* and Hobbes's apparent appeal to one at the

beginning of *Leviathan* chapter 17. Gauthier (1997, 520) takes Hobbes's account of constructing a commonwealth as what we must do if we are to achieve the end of preservation, and this he argues has *no parallel* in geometrical construction. Carter (1999, 82) claims that we must read this appeal to a final cause as actually *teleological* since the peace toward people are directed is something that does not exist, and this is unlike the case of attraction toward a neighbor's possession, which could be explained by appeal only to efficient causes.

It is uncertain how much weight we should give to interlocutor B's claim—not necessarily Hobbes's view—in *Decameron Physiologicum* 2. By 'final cause' or 'end' here, I take it that Hobbes is describing a fact about human psychology—some of the passions "incline men toward peace." The driving passions already discussed include "fear of death, desire of such things as are necessary to commodious living, and hope by their industry to attain them", and reason suggests that it is convenient to covenant with one another and draw up "articles of peace" (EW III.115-116). So by 'end' or 'final cause' here in *Leviathan* 17, Hobbes is merely describing that toward which human passions, understood as endeavours (*conatus*), are directed. Although Gauthier claims that the passions and their ends have no parallel in geometry, this misses Hobbes's identification of the passions as endeavours. Passions are merely the motions that move humans, just like the motions that move points in geometry to form lines. Given this way of understanding the passions and the motions in geometry, *pace* Gauthier, Hobbes's discussion of the final cause of the commonwealth, which is licensed since here he is considering humans who have "sense and will," is, in fact, a point of connection between commonwealth construction and geometrical construction.

6.3.2 The Maker(s) of the Commonwealth versus The Maker in Geometry

6.3.2.1 Maker's Knowledge for Those Who enter the Covenant?

It seems initially plausible that Hobbes thought maker's knowledge was available in political philosophy because of the covenant which each person *makes*, each one with each other. On this view, *each person in the commonwealth has maker's knowledge of the artificial body which is constructed*. Although it may have initial plausibility, I will argue that it is difficult to align what happens in the commonwealth with Hobbes's views on maker's knowledge in geometry. Throughout this section, the subtitle of the *Leviathan* is important to keep in mind: *The Matter, Form, and Power of A Commonwealth, Ecclesiastical and Civil*. Those who come together and covenant primarily play the role of the *matter*—the bodies—of the commonwealth; they are literally the matter out of which the commonwealth is composed.[174]

In this subsection, I consider two additional interrelated differences that seem to prevent maker's knowledge in the commonwealth from being like maker's knowledge in geometry. First, that there must be prearranged agreement about the meanings of names before commonwealth construction begins. Second, that the number of people involved in "making" the commonwealth seems to preclude any one of the authorizers from having a full conception of the causes. This second difference alone would seem to prevent maker's knowledge in political philosophy from being possible. To remove these apparent differences between constructing commonwealths and geometrical figures, in the next subsection I will argue that *only the sovereign has maker's*

[174] Martinich (2002, 365) argues that 'matter' refers to civil government and 'form' refers to ecclesiastical government, speculating that the crown on the side of the 'civil' and the miter on the side of 'form' may depict this visually.

knowledge of the commonwealth when he constructs the commonwealth in his mind beginning from the state of nature.

Individuals construct a geometrical figure with a compass and straight edge by themselves when they encounter a definition that provides them with the mechanical procedure for that construction (or when a teacher provides them with such a definition). So when an individual comes upon the definition of a line as "the motion of a point" and understands those words correctly, she will understand how to *make* a line, construct it and then have maker's knowledge of 'line'. As I have argued in chapter 3, such geometrical construction is a paradigmatic instance of *scientia* for Hobbes.

But how are we to understand Hobbes's connection of maker's knowledge to "politics and ethics"? How well does this first-person model of scientific knowledge which we find in his discussions of geometry fit with what happens in the construction of a commonwealth? In *De homine* 10.5, he argues that

> [...] politics and ethics (that is, the sciences of *just* and *unjust*, of *equity* and *inequity*) can be demonstrated *a priori*; because we ourselves make the principles—that is, the causes of justice (namely laws and covenants)—whereby it is known what *justice* and *equity*, and their opposites *injustice* and *inequity*, are (Hobbes 1994a, 42-43).

Similarly, in *Six Lessons* Hobbes claims that "civil philosophy is demonstrable because we make the commonwealth ourselves" (EW VII.184).

But who counts as the "we" who possess maker's knowledge? To begin answering this question, let us first examine the steps in making a commonwealth described in *Leviathan* XVII. First, a group of individuals must gather together as a multitude. Second, they must agree "to

confer all their power and strength upon one man, or upon one assembly of men, that may reduce all their wills, by plurality of voices, unto one will" (EW III.157). This second step requires an intermediate step—each person must "acknowledge" that he will be the "author of whatsoever he that so beareth their person shall act or cause to be acted in those things which concern the common peace and safety" (EW III.157-158). Third, these individuals must covenant with each other, as represented in what they say to each other: "I authorize and give up my right of governing myself, to this man, or to this assembly of men, on this condition, that thou give up thy right to him, and authorize all his actions in like manner" (EW III.158).

McNeilly worries that Hobbes provides two distinct formulations of this covenant, calling the first the "unanimity formula" and the second the "majority formula" (1968, 218ff). On the first, I authorize the sovereign on the condition that *everyone* else does, and on the second I authorize the sovereign on the condition that the *majority* of everyone else does. McNeilly claims to find these distinct readings in the two formulations of the covenant in *Leviathan* 17 and in *Leviathan* 18, respectively. McNeilly's reading does not appear to be represented in the text, and the most straightforward reading of each formulation is that each person covenants individually with each other person, so that the emergent group-level effect of these individual actions results in the creation of the commonwealth.

This covenant, by which each person authorizes the sovereign, conditional upon every other person's authorization of the sovereign, is more than mere "consent" or "concord." It is what Hobbes describes as "a real unity of them all, in one and the same person" (EW III.158). This real unity is "the generation of that great Leviathan, or rather to speak more reverently, of that mortal god to which we owe under the immortal God our peace and defence" (EW III.158).

Before returning to consider how these actions relate to geometrical construction and maker's knowledge, it will be useful to discuss in more detail what is required for the second and third steps. In the second step, Hobbes's account of the ability to authorize the sovereign depends upon his distinction between actors and authors in *Leviathan* XVI, already discussed. The individual's conditional authorizing and covenanting of each person with each other person is what makes the commonwealth a true unity and not mere consent.

For this covenanting to occur, those who come together must make use of preexisting agreement about names. After providing the third definition of 'philosophy' in *De corpore*, Hobbes discusses a prerequisite for the first route:

> There are, therefore, two methods of philosophy; one, from the generation of things to their possible effects; and the other, from their effects or appearances to some possible generation of the same. In the former of these the truth of the first principles of our ratiocination, namely definitions, is made and constituted by ourselves, whilst we consent and agree about the appellations of things (EW I.388-389).[175]

Some have taken Hobbes's claim that these definitional starting points are "made and constituted by ourselves" to support a conventionalist interpretation of Hobbesian natural philosophy (e.g., Martinich 1997; 2005). On the conventionalist interpretation, definitions are decided at the whim

[175] If one interprets the second sentence outside of the larger context in which I situate my account, there may appear two, equally plausible ways of reading 'whilst' (I refer to the Latin text below, since the Molesworth EW edition is an untrustworthy guide). On the first reading, one takes 'whilst' to be the beginning of an appositional phrase designed to flesh out to what the "making" and "constituting" in the preceding phrase refers. On the second reading, one takes 'whilst' to be describing a necessary condition for the "making" and "constituting." I take the second reading to be most in line with Hobbes's account since when we provide a generative definition, e.g., for something like 'line', we must already have settled which conceptions are being referred to when we use particular names like 'point'. The Latin text supports this latter reading (*per consensionem circa rerum appelationes*, OL I.316) if we take *per* to be expressing the means by which we ourselves make true the first principles of our ratiocination. That is, we must already have this agreement in place about the things to which particular appellations refer before we move to constructive definitions.

of the philosopher, or perhaps the sovereign, but given the present discussion about Hobbes's views on construction the conventionalist view seems untenable. When Hobbes says we *make* and *constitute* definitions, he simply means that we do so by engaging in construction and then providing generative definitions from those constructions.[176]

I wish to draw attention to what follows this claim—that our ability to provide definitions of what we construct *depends* upon our consenting and agreeing on the names or appellations of things. One might think that perhaps these already-agreed-upon names have a similar status in the commonwealth as *simplest conceptions* in geometry and first philosophy, but this is not the case. Importantly, we will not use simplest conceptions in the definition of 'commonwealth' like we do in our definition of 'line'. In fact, we will not be working at the level of conceptions at all when constructing commonwealths, as we do in geometry (we work with conceptions in geometry since we construct by ourselves); instead, since we construct with others and require their cooperation for the construction to work, we will be working with public signs, not personal marks or our own conceptions. As a result, to engage in the conditional covenant we will need to agree about names such as 'person', 'covenant', 'author', and so on.

This prerequisite status of the agreement about names explains some of Hobbes's emphasis in *Leviathan* upon the use of words. My point is not to discuss Hobbes's account of making sure that the signs used connect properly with conceptions that we receive in experience, something that Hobbes argues we do by means of a process that he calls "meditation" at various points in *Leviathan* (e.g., EW III.22; EW III.24; EW III.96; EW III.269).[177] Instead, my goal is

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[176] For further arguments against the conventionalist view, see Adams (forthcoming).

[177] Hobbes does not use 'meditate' in the tradition of religious authors such as Loyola and Augustine, the tradition by which some have taken Descartes's *Meditations on First Philosophy* to be influenced. Instead, Hobbes's use of 'meditate' refers to the process of inspecting one's definitions to be sure that the terms used in them correspond to conceptions received in experience. I discuss this more in another paper (Adams forthcoming). Hobbes's use of

to highlight the individualistic nature of geometrical construction from one's conceptions and to contrast that with the social nature of commonwealth construction from agreed-upon names.

But where is maker's knowledge in the construction of the commonwealth if we hold that each person who conditionally covenants possesses maker's knowledge? One roadblock to the individuals who create the commonwealth possessing maker's knowledge is that, unlike in the case of geometrical construction, no single individual of the people who come together to *agree*, *confer*, *reduce*, *acknowledge*, *covenant*, and *authorize* possesses a complete conception of the causes of the entire commonwealth.

Whereas in the case of geometrical construction one individual alone is necessary to move a point to form a line and to move a line to form a surface, in the case of the commonwealth each individual is only one small component of the total cause of the commonwealth. Thus, no individual engaging jointly in all these actions (*agree*, *confer*, *reduce*, *acknowledge*, *covenant*, and *authorize*) with the other individuals will have maker's knowledge of the commonwealth since no individual by herself will be able to conceive of the total cause. If we take Hobbes strictly as arguing that we have causal knowledge of something only when we ourselves are the maker of *that thing* or things of *that kind* (e.g., circles in general when we have made at least one circle), then if other makers are involved we are precluded from having causal knowledge of what they make with us.

The problem with this initially plausible view that the covenanters have maker's knowledge is that geometry provides a first person model of maker's knowledge wherein each person alone makes something *completely*. I know the causes of that which I create because *I* am

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'meditate' has more in common with what is described in a section entitled *De methodo meditationis* of Honoré Fabri's 1646 textbook *Philosophiae tomus primus: Qui complectitur scientiarum methodum sex libris explicatam*. Although not focused on conceptions as Hobbes's account is, the reader is instructed to do the following while meditating: "Examine diligently", "Interrogate yourself", and so on (see discussion in Dear 1995b, 57-62, here 58).

the creator, not someone else with me. If I drew half a circle and someone else came and completed the other half (partially analogous to Hobbes's example of encountering an already constructed circle at *De corpore* 1.5, OL I.5-6), I would not know the causes of *that* circle because I did not fully make it. This is the situation for the commonwealth. We cannot on our own construct the commonwealth and, as a result, we cannot fully conceive its causes. In other words, with the commonwealth, as with natural things, "the causes […] are not in our power" (Hobbes 1994a, 42). So how is it possible that we demonstrate effects from "conceived (*ex conceptis*) causes or generations" (OL I.2), i.e., the first path of philosophy described above, if we cannot have a complete conception of the causes of the commonwealth?

A way out of this difficulty would be to broaden maker's knowledge beyond first person knowledge. Perhaps one has only to have *partial causal knowledge*, like those who construct a commonwealth together, to have maker's knowledge. I do not think that this route will work, since it detracts from much of the intuitive appeal of the maker's knowledge view.

Alternatively, we might say that in the case of the commonwealth somehow the action of our conditional covenanting gives us knowledge of the causes even though we ourselves do not bring about the commonwealth alone. Perhaps we have such knowledge because we are engaging in a *joint action*,[178] and this may be the difference between mere consent and the real unity which Hobbes believes the commonwealth is. While such a solution would seem to deal with some of the issues that I have raised, I do not believe that there is sufficient textual support to give us reason to think that this is how Hobbes or his contemporaries would have seen the matter. Furthermore, in the state of nature we can join with another person to defeat a third party,

[178] Although not concerned with the issue of maker's knowledge, Rawls claims in *A Theory of Justice* that those choosing behind the veil do so "in one joint act" (1999, 10).

assuming that we think that our own interests will be served by doing so. This as well is a form of joint action, but it is certainly not something that Hobbes would want to call a real unity.

6.3.2.2 The Sovereign as Maker and Politics as Mixed Mathematics

Given these limitations to extending maker's knowledge to the covenanters who are the *matter* of the commonwealth, it is clear that those who come together to form a commonwealth cannot have maker's knowledge. But where does this leave Hobbes's claims that there is maker's knowledge in political philosophy just like there is in geometry? Instead of viewing the mass of individuals who come together as the makers, I argue that Hobbes held that the *sovereign is the maker* and that the sovereign acts as a maker only when carrying out the state of nature thought experiment and continuing until the construction of the commonwealth in his mind. I argue for this claim in two steps: first, I distinguish the making that seems to occur in enacting conditional covenants and from the making by analysis and synthesis which a sovereign, or what we might anachronistically call a political scientist, does; and second, I contend we should understand the explanation of the commonwealth in *Leviathan* XVII as a mixed mathematics explanation.

In chapter 3, I argued that for Hobbes it does not matter whether one constructs geometrical figures using a compass and straight edge or using conceptions in one's mind. In either case, one has maker's knowledge of what is constructed; this makes it possible for there to be maker's knowledge in first philosophy (as I argued in chapter 3) and also in human science (as I argued earlier). So, for example, one might imagine in one's mind a point moving and arrive at a proper conception of 'line'; such an action would provide one with maker's knowledge of 'line'. One could also analyze the conception of a square and then compound it back together in synthesis; as a result one would learn "the cause of the square" (OL I.61).

The same holds for commonwealth construction. To have maker's knowledge of the commonwealth one does not need to construct an *actual* commonwealth nor does one need to be one of the actual persons involved in its genesis. The view that maker's knowledge is possessed by those who conditionally covenant with one another presupposed this. However, this is too strict a constraint, and if Hobbes had held such a view about the limited scope of maker's knowledge in political philosophy one might wonder why he was so concerned with having a *science of politics* that would benefit his current political climate.[179]

So let us distinguish between the following: persons who make the commonwealth by composing it in their minds and those who both seem to make insofar as they covenant and become the matter from which the commonwealth is made. Those in the first group can be anyone who reads the *Leviathan* and actively participates—by constructing in her mind—in the state of nature thought experiment. The second group consists of only those persons who were actually present when the commonwealth was founded. Importantly, this second group's role is both passive and active in the construction of the commonwealth; this group consists of those who are both "the matter [...] and the artificer", as Hobbes states in the Introduction to *Leviathan* (EW III.x). They *seem* active in their conditional covenanting with one another, but their primary role is passive. They are passive in that they are merely the bodies out of which the commonwealth is made. More importantly, no single person in this group can be the *total* artificer of the commonwealth, since none has the complete conception of it. As a result, they simply cannot possess maker's knowledge of the commonwealth.

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[179] For example, see the Preface to *De cive* (Hobbes 1983b, 35) and also the Review and Conclusion to *Leviathan* (Hobbes 1994b, 496).

Persons who imagine the state of nature in their minds could be anyone who acts as a political scientist, as it were, but Hobbes had sovereigns in mind when he composed the *Leviathan*:

> But let one man read another by his actions never so perfectly, it serves him only with his acquaintance, which are but few. *He that is to govern a whole nation* must read in himself, not this or that particular man, but mankind, which though it be hard to do, harder than to learn any language or science, yet when I shall have set down my own reading orderly and perspicuously, the pains of another will be only to consider if he also does not find the same in himself. For this kind of doctrine admitteth no other demonstration (EW III.xi; emphasis added).

Leviathan is a book written for sovereigns, and as the end result, Hobbes desires that any sovereign who reads it will be able to understand, or what Hobbes calls "read," *all humans*. This sovereign will have maker's knowledge (*scientia*) of the commonwealth because he will know humanity, not merely his own nature or that of those nearest to him.

The process of seeing whether "he also does not find the same in himself" is accomplished not by mere self-reflection or casual introspection, but rather, I argue, by going through the constructive process in *Leviathan*. One must construct the commonwealth in one's mind by entertaining the state of nature thought experiment oneself, seeing that the driving passions incline humans in that state toward peace, and then beginning the construction of the commonwealth. Recall the distinction made earlier between the "inference made from the passions" and consulting one's own experience. Reading all of humanity requires such an inference; one may "confirm" the inference by examining the motions of one's own mind, but doing so will not provide *scientia*.

Furthermore, Hobbes holds that a sovereign does not need to learn geometry or natural philosophy, for these are not the starting points of human science or political philosophy. The starting points are 'human' and 'passion', which function like 'body' and 'motion' in geometry in geometry and first philosophy. As a result, Hobbes argues in *Leviathan* XXXI that sovereigns need not know geometry or natural philosophy:

> [...] *the science of natural justice is the only science necessary for sovereigns and their principle ministers*; and that they need not be charged with the sciences mathematical (as by Plato they are) further than by good laws to encourage men to study them; and that neither Plato, nor any other philosopher hitherto, hath put into order, and sufficiently or probably, proved all the theorems of moral doctrine, that men may learn thereby both how to govern and how to obey; I recover some hope that [...] this writing of mine *may fall into the hands of a sovereign who will consider it in himself* [...], without the help of any interested or envious interpreter, and by the exercise of entire sovereignty in protecting the public teaching of it, convert this truth of speculation into the utility of practice (Hobbes 1994b, 243-244; EW III.357-358; emphasis added).

These starting points of 'human' and 'passion' are the beginning points of construction for the sovereign. As with his earlier claim that a sovereign must read in himself, Hobbes's desire in *Leviathan* XXXI that some later sovereign "consider it in himself" refers to the sovereign's need to construct in his mind.

So far I have argued that Hobbes's political philosophy is unified with his geometry and first philosophy, as well as with his natural philosophy, by showing how sovereigns who construct in the state of nature thought experiment in human science have maker's knowledge of

human nature. The dependence of *political philosophy* (*Leviathan* Part II) upon *human science* (*Leviathan* Part I), especially with the account of the driving passions, makes maker's knowledge essential for Hobbes's explanation of the commonwealth in *Leviathan* XVII. In what remains of the present chapter, I argue that the explanation of the genesis of the commonwealth, like Hobbes's explanations in natural philosophy, takes the form of a mixed mathematics explanation, where in this case the causal principles are borrowed from human science.

Hobbes begins *Leviathan* XVII with the final cause of the commonwealth. These principles relating to the driving passions are *borrowed* from human science and are not demonstrated in chapter XVII, which is the beginning of Part II on politics. They are borrowed just like geometrical principles are borrowed in the natural philosophy of *De corpore* Part IV. Although these driving passions incline toward peace, they do not in themselves supply what is necessary for their satisfaction; they simply incline humans in the state of nature toward peace.

Several appeals to everyday *experience* follow this appeal to the driving passions in *Leviathan* XVII; these constitute Hobbes's appeal to the *hoti* in this mixed-mathematics-style explanation. The laws of nature do not provide in themselves the ability to satisfy these driving passions (EW III.153-154). This claim is not demonstrated by appealing back to the discussions of the laws of nature in human science; instead, Hobbes appeals to everyday sense experience.

> And in all places where men have lived by small families, to rob and spoil one another has been a trade, and so far from being reputed against the law of nature that the greater spoils they gained, the greater was their honour; and men observed no other laws therein, but the laws of honour; that is, to abstain from cruelty, leaving to men their lives and instruments of husbandry (EW III.154; Hobbes 1994a, 106-107).

Even if there are "cities and kingdoms" instead of small families, Hobbes still thinks that between these larger entities there will still be nothing available that will enable the driving passions to be satisfied.

The security and peace sought by the driving passions is also not available simply by adding additional persons to small groups of individuals or even groups of families. One might have thought that even if robbing and spoiling were the "trade" among small families, perhaps one family could have enjoyed security and peace by having enough persons. However, this will not provide the satisfaction that Hobbes believes is required by the driving passions. The problem is that "the multitude sufficient to confide in for our security, is not determined by an certain number but by comparison with the enemy we fear [...]" (EW III.154-155). Regardless of how many persons are added to a group, all that is required is "small additions on one side or the other" to upset the power differential (EW III.154).

But perhaps one might think that the end sought by the passions could be reached if one simply had a large enough group, or what Hobbes calls a "great multitude." The problem with such a case is that *no matter how large the group*, individuals within the group will each have "particular judgments" and "particular appetites" by which they will be directed to actions that conflict against their supposedly common goals.

> For being distracted in opinions concerning the best use and application of their strength, they do not help but hinder one another; and reduce their strength by mutual opposition to nothing: whereby they are easily, not only subdued by a very few that agree together; but also when there is no common enemy, they make war upon each other, for their particular interests (EW III.155).

This claim is also demonstrated by experience by means of a *reductio ad absurdum* argument. Hobbes argues that we cannot even suppose such a large group to be able to have consent with another with regard to regulating their individual passions which conflict with one another.

For he argues that "if we could suppose a great multitude of mean" to be able to have such consent, then "we might as well suppose all mankind to do the same; and then *there neither would be, nor need to be any civil government, or commonwealth at all*; because there would be peace without subjection" (EW III.155; emphasis added). Since of course there are, in fact, commonwealths this makes absurd the supposition for the sake of *reductio*, namely, that such a multitude could have such consent.

Further difficulty would be raised for thinking that such a large group could have peace by imagining what happens after the members of such a group are victorious over their common enemy. In such a case, Hobbes argues that "when they have no common enemy" or when some members of the group are divided against each other it is necessary to "dissolve and fall again into a war amongst themselves" (EW III.155-156). The satisfaction of the three driving passions we have discussed requires a more lasting peace than what is available through the formation of a large group.

Everyday experience also plays a role Hobbes's consideration of a set of potential objections from someone who, like Aristotle, sees humans as "numbered amongst political creatures" (EW III.156). Without specifying the details that he provides for each of these six possible objections, it is evident that he is here relying on observations about the behaviors of these animals and comparing these behaviors with those observed of humans. Even if Hobbes does not provide detailed accounts of his observations, these are not mere "self-evident truths" about human behavior, *pace* Peters (1967, 144). Like in his natural philosophy, here we see

Hobbes bringing in everyday sensory experience—the *hoti*—as part of his explanation for the genesis of the commonwealth.

The driving passions will be satisfied only when there is a common power with full authority: "The *only way* to erect such a power [by covenant], as may be able to defend them from the invasion of foreigners, and the injuries of one another, and thereby to secure them in such sort, as that by their own industry, and by the fruits of the earth, they may nourish, themselves and live contentedly; is, to confer all their power and strength upon one man, or upon one assembly of men, that may reduce all their wills, by plurality of voices, unto one will [...]" (EW III.158; emphasis added). Hobbes sees this as the *only way* because he sees this office as providing long-lasting peace; such continuity is the only way to provide an assurance of peace (cf. EW III.113).

In the explanation for the genesis of the commonwealth, we have seen a mixture of causal principles, which are the *dioti* borrowed from human science in *Leviathan* Part I, with appeals to everyday experience, which are the *hoti*. These are mixed together in a single explanation in chapter XVII so that when combined together in its definition they explain the genesis and nature of the commonwealth (EW III.158). The Table of the Several Subjects of the Science in *Leviathan* IX makes clear that what I have called human science and commonwealth science are distinct disciplines. Human science is under physics, but commonwealth science is its own science. Seeing the explanation of the commonwealth as a mixed-mathematical explanation shows how this division can be the case for Hobbes. The use of the causal principles from human science in the explanation of the commonwealth is permissible because, like the relationship between geometry and natural philosophy, human science is an abstract science wherein we discover causes that can then be "mixed" in the explanation of the commonwealth.

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